145 JAN 4 1943

Vol. 70 JANUARY, 1943 No. 1

Bulletin

of the

Torrey Botanical Club

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Published for the Club bi-monthly

by

THE SCIENCE PRESS PRINTING COMPANY
N. QUEEN ST. AND McGOVERN AVE.
LANCASTER, PENNSYLVANIA

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The Bulletin of the Torrey Botanical Club

Beginning with this issue the Bulletin will be published every alternate month instead of monthly as heretofore.

Subscriptions, dues, and inquiries about back numbers should be sent to the office of publication, N. Queen St. and McGovern Ave., Lancaster, Pa., or to Dr. W. G. Whaley, Department of Botany, Barnard College, New York, N. Y. Correspondence about advertisements and circulation should be addressed to Dr. Michael Levine, Montefiore Hospital, New York, N. Y. Communications about exchanges should be sent to Dr. Harold C. Bold, Department of Botany, Barnard College, New York, N. Y. Manuscripts intended for the Bulletin should be sent to Dr. H. W. Rickett, The New York Botanical Garden, Bronx Park (Fordham Branch P. O.), New York, N. Y.

Claims for missing numbers must be made within 60 days from the date of issue.

The subscription price of the Bulletin of the Torrey Botanical Club is $3.00 a year except to active members of the Club. Of the annual membership dues, $3.00 covers a year's subscription to the Bulletin.

Torreya. Bimonthly; established 1901. Of the annual dues $0.50 is for a year's subscription to Torreya; price to non-members, $1.00.

Entered as second-class matter October 8, 1940 at the post office at Lancaster, Pa., under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph 4, section 538, P. L. & R.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 1–14 JANUARY, 1943

THE MICROBIOLOGY OF THE UPPER AIR[1]

FRED T. WOLF

A most important development in the study of microorganisms occurring in the upper air is marked by the work of Stakman et al. (1923), who were the first to make use of the airplane for microbiological work, in collecting fungus spores from altitudes of as much as 16,500 feet. Soon afterward, Mischustin (1926) isolated numerous bacteria upon plates of nutrient media exposed from airplanes above the city of Moscow. Although bacteria, fungus spores, and pollen grains compose by far the greater portion of the aerial flora, the finding of actinomycetes, yeasts, algae, and moss spores (van Overeem, 1936) at considerable altitudes has resulted in the establishment of aerobiology as a fertile field of microbiological research.

The apparatus and techniques employed in collecting and studying organisms from the air have necessarily been diverse. Glass slides coated with vaseline or glycerine jelly and examined microscopically, or Petri dishes containing nutrient media for cultural studies have been used by many investigators. Among the more elaborate appliances that have been devised may be mentioned the ingenious apparatus for use with balloons, developed by Chatterjee (1931), the "sky hook" of Meier and Lindbergh (1935), the parachute apparatus of Rogers and Meier (1936) for collecting bacteria from the stratosphere, the apparatus of van Overeem (1936), and the bioaerocollector of Proctor and Parker (1938). The various types of apparatus, the techniques of using them, and the evaluation of data obtained by their use have been discussed in recent articles on aerobiological methods by Durham (1941) and the Committee on Apparatus in Aerobiology (1941).

The results of efforts to collect microorganisms from air over the ocean remote from land (Bisby 1935; Meier 1936a; Meier and Lindbergh 1935; Rittenberg 1939; Durham 1941) show that organisms in the air can be transported for long distances. Durham (1938a) has described a movement of air masses in which *Alternaria* spores, originating in Minnesota, were carried to the Atlantic and Gulf coasts in about fifty-five hours, and in which "thousands of tons of mold spores were transported an average distance of several hundred miles."

The practical importance of aerobiological investigations is well illustrated in the field of plant pathology by studies of spore dissemination in the cereal rusts made by Stakman et al. (1923), Craigie and Popp (1928),

[1] Paper presented before the Association of Southeastern Biologists in Miami, Florida, on April 17, 1942.

[THE BULLETIN for December (69: 627–711) was issued December 2, 1942]

Peturson (1931), and Hubert (1932). The incidence of air-borne fungus spores in relation to human allergy has been extensively studied by Durham (1937, 1938a) and others, while studies on air-borne pollen grains in relation to allergic conditions in man are so numerous as to be entirely beyond the scope of this brief review.

Just how far above the surface of the earth living organisms exist is still an unanswered question. Stakman et al. (1923) and Meier, Stevenson, and Charles (1933) report a decided decrease in the number of microorganisms above 8,000–11,000 feet. Walker (1935) failed to find bacteria above an altitude of 19,000 feet. On the other hand Proctor (1934) reported that bacteria and fungus spores were obtained at the greatest altitudes studied by him, namely, at 20,000 feet. Stevens (1936) and Rogers and Meier (1936) reported the isolation of bacteria and fungus spores from the stratosphere at altitudes in excess of 36,000 feet.

In order to remain viable at high altitudes, organisms must be highly resistant to fluctuations in temperature, atmospheric pressure, and humidity, and to exposure to large amounts of ultraviolet radiation (Proctor 1934; Meier 1936b; Jacobs 1939). In spite of these environmental factors unfavorable for microorganisms, a surprisingly large number of forms have been found to occur at considerable altitudes. The bacterial flora of the air has been investigated by Mischustin (1926), Proctor (1934, 1935), Walker (1935), Rogers and Meier (1936), Proctor and Parker (1938), and Rittenberg (1939). Forty-nine species of eight genera, including spore-forming rods, non-spore-forming rods, and cocci have been identified by Proctor et al. The fungus flora of the air is even more diverse, and representatives of some forty genera, chiefly Fungi Imperfecti, but also including rusts, smuts, ascomycetes, and Mucorales, have been found at altitudes of several thousand feet (Brown 1930; Meier, Stevenson and Charles 1933; Proctor 1934, 1935; Meier and Lindbergh 1935; MacQuiddy 1935; Durham 1937, 1938; Tasugi and Kurosawa 1938; Rittenberg 1939).

MATERIALS AND METHODS

The present studies were undertaken in order to determine the kinds of microorganisms present at various altitudes in the air over Nashville, Tennessee, to obtain quantitative data as to relative prevalence of the various kinds, and to attempt to correlate these data with existing weather conditions. Six flights were made from Berry Field, Nashville, during the months of October, November, and December, 1941, and January and February, 1942.

No exposures were made at altitudes of less than 1,000 feet, in order to rule out the rather large amount of contamination from the surface of the earth experienced below this level. The first three flights, on October 19,

October 26, and November 9 were made at comparatively low altitudes of 1,000–2,000 feet, and were of a preliminary nature, devoted to becoming familiar with the manipulation of apparatus, to determining proper times of exposure, and to gaining some indication of types of organisms to be found. On December 6, plates were exposed at intervals of 1,000 feet of altitude (on both the ascent and descent) up to a maximum of 10,600 feet. Similar exposures, at lesser intervals of altitude, up to maxima of 6,000 feet and 3,500 feet were made on January 25 and February 22, respectively.

The technique employed consisted in exposing Petri dishes containing ordinary nutrient agar (beef extract, 3 gm.; Bactopeptone, 5 gm.; agar, 15 gm.; distilled water, to make 1,000 cc.). In order to guard against contamination, and also to lessen the condensation of moisture during the sudden cooling incident to exposure, the plates were poured two days prior to use. The dishes were kept firmly closed, except during exposure, by heavy rubber bands. Exposures were made, generally for a thirty-second period, by extending the dish at arm's length from the cabin window, removing the top and replacing it by hand.

Although the plates were exposed in the disturbed air in the wake of the propeller, it has been demonstrated by Meier and Lindbergh (1935) that the rush of air during the early stages of flight thoroughly removes dust particles from the surfaces of the plane, so that contamination from this source must be regarded as unlikely. This conclusion is supported by the occasional occurrence of a sterile Petri dish, following an exposure of thirty seconds to the air stream, as well as by the data concerning the decrease in organisms at increasing altitudes. Approximately seventy-five plates were exposed in the course of this work. Adequate controls were provided by two plates, carried along at each flight, but unexposed, in which no colonies developed after incubation.

For each flight, records of the ground dry-bulb temperature, wet-bulb temperature (dew point), relative humidity, wind direction, wind velocity, and cloud formations were provided by the Weather Bureau. On the December 6 flight to 10,600 feet, supplementary readings of the air temperature at various altitudes were obtained from a thermometer mounted on the wing strut. For each plate exposed, records of the altitude, the length of the exposure (usually thirty seconds), and the air speed of the plane were taken. From this information, the area of the surface of the Petri dish exposed, and the counts of colonies which developed upon incubation of the plates, quantitative data as to the number of organisms present per cubic foot of air at the various altitudes were secured.

The plates were incubated at room temperature for seventy-two hours, at which time counts were made of the number of bacterial and fungus colonies. Yeasts and actinomycetes were included with the bacteria in these

counts. From each macroscopically distinct type of colony developing on each plate, transfers were made to slants of nutrient agar, and the resulting cultures were used in identification of the various organisms collected.

BACTERIA

Previous investigations, including those of Mischustin (1926), Walker (1935), Proctor (1934, 1935), Rogers and Meier (1936), Proctor and Parker (1938) and Rittenberg (1939), have disclosed that in the upper air bacteria are far more numerous than fungus spores or other organisms. Counts of bacterial colonies were made on all the plates exposed, and a limited number of them, including the plates exposed at the 6,000–10,600 ft. levels on December 6, 4,000–6,000 ft. on January 25, and 2,000–3,500 ft. on February 22 were selected for detailed taxonomic studies.

From these plates, sixty-one isolates, representing twenty-nine distinct species, were identified according to the characteristics given in the fifth

TABLE 1

Bacteria found in the upper air

The figures indicate the number of isolates of each species which were identified

	Dec. 6	Jan. 25	Feb. 22	Total
Achromobacter cystinovorum Barber and Burrows	0	1	0	1
Achromobacter guttatum (Zimmermann) Bergey	0	1	0	1
Achromobacter liquidum (Frankland and Frankland) Bergey	0	0	1	1
Bacillus adhaerens Laubach	0	1	1	2
Bacillus agri Laubach and Rice	0	3	1	4
Bacillus cereus Frankland and Frankland	1	2	0	3
Bacillus fusiformis Gottheil	0	0	1	1
Bacillus megatherium DeBary	2	1	1	4
Bacillus mesentericus Trevisan	0	4	0	4
Bacillus mycoides Flügge	0	0	1	1
Bacillus subtilis Cohn	0	3	0	3
Bacillus ubicuitarius Soriano	0	1	0	1
Flavobacterium devorans (Zimmermann) Bergey	2	1	0	3
Flavobacterium fuscum (Zimmermann) Bergey	0	0	1	1
Flavobacterium lacunatum (Wright) Bergey	0	0	1	1
Flavobacterium sulfureum Bergey	0	2	1	3
Micrococcus aurantiacus (Schröter) Cohn	0	0	1	1
Micrococcus candicans Flügge	1	0	0	1
Micrococcus conglomeratus Migula	1	0	0	1
Micrococcus corallinus Cantani	0	1	0	1
Micrococcus flavus Lehmann and Neumann	0	0	3	3
Micrococcus freudenreichii Guillebeau	4	1	3	8
Micrococcus luteus (Schröter) Cohn	0	0	1	1
Micrococcus perflavus Bergey	0	0	1	1
Micrococcus rosaccus Frankland and Frankland	1	0	0	1
Micrococcus subcitreus Migula	1	1	0	2
Pseudomonas striata Chester	0	1	0	1
Sarcina flava DeBary	2	1	0	3
Serratia plymouthensis (Migula) Bergey	1	0	2	3

edition of Bergey's *Manual of Determinative Bacteriology*. The species found, and the number of cultures of each which were identified, is presented in table 1.

Spore-forming rods, of the genus Bacillus, comprise 37.7 per cent of the cultures, while 24.6 per cent are non-spore-forming rods, and 37.7 per cent are cocci. A comparison may be made with the figures 52.2 per cent, 20.0 per cent and 27.8 per cent respectively, cited by Proctor (1934), showing that fewer spore-formers and more cocci occurred among the present collections.

All of the spore-forming rods collected proved to be Gram positive. Likewise all of the cocci (with the exception of two Gram variable organisms) were Gram-positive. Both Gram-negative and Gram-positive non-spore-forming rods were obtained, however, the former group being the more numerous.

It is of more than passing interest to compare the present list of bacteria with the forty-nine species collected by Proctor (1934, 1935) and Proctor and Parker (1938). Eleven species; namely, *Bacillus cereus, B. megatherium, B. mesentericus, B. mycoides, B. subtilis, Micrococcus candidus, M. coralinus, M. conglomeratus, M. flavus, M. perflavus,* and *Sarcina flava* are to be found in both lists. The similarities between the two studies are, however, greater than is shown by the number of identical species. Proctor et al. list three species of *Flavobacterium* and seven species of *Achromobacter*. The present list includes four species of *Flavobacterium* and three of *Achromobacter*, but no single species is common to both lists. Proctor found only two genera not isolated at Nashville, namely *Kurthia* and *Staphylococcus*, and the present list has only two genera, *Pseudomonas* and *Serratia*, not found by him. If one makes allowance for the fact that the same genera may be represented by different species, and that many of Proctor's cultures were isolated from altitudes greater than those studied by us, the accordance between the two lists is very close.

The findings of Proctor (1934) and Rittenberg (1939) that aerial bacteria generally are of types commonly found in soil or water, that they are in general unable to ferment the common sugars with formation of gas, and that they are characteristically unable to produce indol is borne out by our studies.

FUNGI

One hundred and twenty isolates, obtained at different altitudes on the various flights, were identified to genus. Except in a few genera, identification to species was difficult or impossible, because of lack of adequate keys and of type cultures for purposes of comparison. The cultures included representatives of one genus of Phycomycetes, one of Ascomycetes, and fourteen genera of the Fungi Imperfecti. Among the latter, most of the

isolates belonged to the families Moniliaceae and Dematiaceae of the Moniliales, the two families being about equally well represented. One genus of the Tuberculariaceae and one of the Phomales were also encountered. The various genera, next to be discussed separately, with the number of cultures studied from the various flights, are listed in table 2.

MUCOR. Two cultures obtained at low altitudes on February 22 were examined by Dr. Victor M. Cutter, Jr., who found that they belong to the section *Micromucor*, and are closely related to *Mucor ramanianus*. Chlamydospores and sporangia, but not zygospores, are produced in culture. Species of *Mucor* and *Rhizopus* have been previously obtained from the upper air by Rogers and Meier (1936) and Tasugi and Kurosawa (1938).

CHAETOMIUM. Two cultures, isolated on December 6 at altitudes of 1,000 and 3,000 feet, were identified as *C. murorum* Corda. The characteristic setosely appendaged perithecia, containing eight-spored asci, are produced abundantly in culture. This genus has previously been found in the aerial flora by Meier, Stevenson and Charles (1933).

ACLADIUM. A single culture, obtained from a plate exposed at 8,000 feet on December 6, was identified as a member of this genus. The conidia are hyaline, globose to ellipsoid, with smooth walls, and are borne in a pleurogenous fashion on simple conidiophores.

ASPERGILLUS. Two species of *Aspergillus* were isolated. On January 25, at an altitude of 3,500 feet, cultures were obtained of a black-spored species of the *A. niger*-group, with minutely spinulose conidia and sterigmata in a single series. This isolate corresponds with the description of *A. luchuensis*.

A. terreus was collected twice, at 5,800 feet on January 25, and again on February 22 at 3,500 feet. It is characterized by yellowish brown conidial heads, bearing both primary and secondary sterigmata.

CEPHALOTHECIUM. Two similar strains of *Cephalothecium* were encountered on January 25 and February 22, both at an altitude of 1,500 feet. The mycelium in culture has a fluffy appearance, and bears capitately groups of two-celled pinkish conidia. The occurrence of this genus in the upper air has been reported by Stakman et al. (1923).

OOSPORA. A single isolate referable to this genus was collected from the 2,200 foot level on February 22.

PENICILLIUM. The only species of *Penicillium* to appear in the present collections was an unidentified form of the group Asymmetrica, obtained on January 25 at an altitude of 2,500 feet.

SCOPULARIOPSIS. At an altitude of 1,600 feet on October 26, a single culture of *Scopulariopsis brevicaulis* (Sacc.) Bain, was obtained. Identification was made by Dr. D. H. Linder. This species, sometimes placed in the genus Penicillium, produces conidia of a cinnamon brown color, with warted walls. It is known to cause infections of the toe-nails and finger-nails in man, and

is perhaps even better known because of its physiological property of breaking down arsenic compounds to liberate arsine.

VERTICILLIUM. Six closely similar isolates of *Verticillium* were collected on October 19, October 26, November 9, and December 6 at altitudes of 1,000–1,500 feet. The mycelium bears numerous lateral whorled conidiophores, each of which bears a single ellipsoid conidium at its tip. The conidia separate so readily from the tips of the conidiophores that it is difficult to find a mature one attached in microscopic preparations. From the evidence at hand, it appears probable that *Verticillium* is almost always present in small quantities in the air over Nashville.

ALTERNARIA. Twenty-seven isolates of *Alternaria* were studied during the course of this work. This genus was collected on all flights except one. Of twenty-one plates exposed on December 6, *Alternaria* was found upon eight, one of which was exposed at an altitude of 7,000 feet. It appears, therefore, that *Alternaria* spores are commonly present in the air in rather large quantities. This finding confirms the experience of Stakman et al. (1923), Meier, Stevenson and Charles (1933), Durham (1937, 1938, 1941), and Tasugi and Kurosawa (1938).

BRACHYSPORIUM. This genus, characterized by two–four celled, dark brown or black phragmosporous conidia, was found only once, at an altitude of 1,000 feet on November 9. It has been reported from the air over Tokyo by Tasugi and Kurosawa (1938).

HELMINTHOSPORIUM. In the experience of many others, including Stakman et al. (1933), Meier, Stevenson and Charles (1933), Durham (1937), and Tasugi and Kurosawa (1938), *Helminthosporium* is of rather common occurrence in the air. Two collections on February 22, at an altitude of 1,500 feet, indicate that the brown, multicellular, elongate spores characteristic of this genus do not appear to be nearly so common near Nashville as elsewhere.

HORMODENDRUM. Twenty-four of the 120 cultures studied belong to the genus *Hormodendrum*. It was isolated on every flight with the exception of the one made on October 26. A culture from one of the earlier flights was identified by Dr. N. F. Conant. Plates exposed on December 6 at altitudes of 10,000 and 10,600 feet contained colonies of *Hormodendrum* but of no other fungi. The large number of isolates obtained, and the consistent collection of this genus in most of the flights indicates that *Hormodendrum* is constantly present in rather large amounts in the air. This result confirms the findings of many other workers, including Stakman et al. (1923), Meier, Stevenson and Charles (1933), Meier and Lindbergh (1935), Proctor and Parker (1938), Tasugi and Kurosawa (1938), Durham (1938), and Rittenberg (1939).

MACROSPORIUM. A species of *Macrosporium* was collected from a low alti-

tude on February 22. This genus has been previously reported from the air by numerous workers, including Brown (1930), Meier, Stevenson and Charles (1933), Meier and Lindbergh (1935), Proctor and Parker (1938) and Tasugi and Kurosawa (1938). It has been reported also from the stratosphere by Rogers and Meier (1936).

FUSARIUM. No less than thirty-five cultures of this genus of the Tuberculariaceae were obtained. *Fusarium* was found on all of the flights made except that on November 9. On February 22, it was collected as high as 3,500 feet, but it appears to be restricted generally to lower altitudes.

Although many of the cultures produce the characteristic four-celled, fusoid, curved conidia in abundance, a considerable number produced no spores whatsoever on nutrient agar. Non-pigment-producing forms were most abundant. Two cultures from the flight of October 19, studied by Dr. C. D. Sherbakoff, were identified by him as *F. reticulatum* Mont. In addition, a few cultures characterized by the production of yellow pigments, and a few producing red pigments were collected.

Although *Fusarium* spores have been previously isolated from the air by Meier, Stevenson and Charles (1933), and Durham (1937, 1941), it would seem that further studies of the aerial dissemination of *Fusarium* spores should be made by plant pathologists, because of the great economic importance of diseases caused by members of this genus.

PLENOZYTHIA. A pycnidium-producing fungus, referable to this genus of the Phomales, was found at an altitude of 6,000 feet, on December 6, and again on February 22 at 3,500 feet. Groups of pycnidia, within which immense numbers of hyaline pycnidiospores are formed, are produced on agar. This genus was found by Rittenberg (1939) in plates exposed on shipboard several hundred miles off the California coast.

From the data assembled in table 2, it is apparent that species of *Alternaria*, *Fusarium*, and *Hormodendrum* make up the greater proportion of the fungi of the air over Nashville, and are practically constantly present. *Verticillium*, also, appears to be constantly present in small amounts. The remaining fungi must be regarded as of sporadic occurrence.

Proctor (1934), Proctor and Parker (1938), and others have found species of *Aspergillus* and *Penicillium* to make up a very large proportion of the fungi isolated from air. The present collections, in which only six of 120 fungus cultures belong to these genera, is in marked contrast to these findings.

It is of interest to compare the present findings with the results of Pennington (1940), who made daily spore counts from slides exposed at the ground level in Nashville. *Hormodendrum*, *Alternaria*, *Spondylocladium*, *Acrothecium*, *Helminthosporium*, and *Fusarium* were the most abundant genera, but smut spores, *Aspergillus terreus*, and other *Aspergilli* were also

obtained. Except for collection of *Spondylocladium*, *Acrothecium*, and smuts, the fungi at the ground level are quite like those in the upper air.

YEASTS

The occurrence of yeasts in the aerial flora has been reported by Brown (1930), Proctor (1934), and Tasugi and Kurosawa (1938). A pink, non-spore-forming species of *Saccharomyces* was found by us on plates exposed at 10,000 feet on December 6, and again at 5,800 feet on January 25.

ACTINOMYCETES

Both Mischustin (1926) and Proctor (1934) have reported that Actinomycetes are represented in the microflora of the air, but have not attempted to identify the species found. *Actinomyces griseolus* was isolated by us from a plate exposed at 4,700 feet altitude on January 25, and at 2,200 feet on February 22. *A. phaeochromogenus* occurred on plates exposed at 2,000 feet on February 22.

OTHER ORGANISMS

Meier and Lindbergh (1935) and van Overeem (1936) collected a number of green algae and diatoms from the air during airplane flights. The latter investigator isolated, from an altitude of 2,000 meters, a "moss protonema, which, transferred to a solid medium, has yielded fair-sized moss plants." In the hope of obtaining algae or other chlorophyll-bearing organ-

TABLE 2

Summary of the various types of fungi collected and their relative abundance on different dates

	Oct. 19	Oct. 26	Nov. 9	Dec. 6	Jan. 25	Feb. 22	Total
Acladium	....	....	....	1	....	....	1
Alternaria	3	....	2	13	6	3	27
Aspergillus	....	....	....	....	3	1	4
Brachysporium	....	....	2	....	....	....	2
Cephalothecium	....	....	....	....	1	1	2
Chaetomium	....	....	....	2	....	....	2
Fusarium	7	11	....	5	2	10	35
Helminthosporium	....	....	....	....	....	2	2
Hormodendrum	3	....	5	12	2	2	24
Macrosporium	....	....	....	....	....	1	1
Mucor	....	....	....	....	....	2	2
Oospora	....	....	....	....	....	1	1
Penicillium	....	....	....	....	2	....	2
Plenozythia	....	....	....	1	....	1	2
Scopulariopsis	....	1	....	....	....	....	1
Verticillium	1	2	2	1	....	....	6
Actinomyces	....	....	....	....	1	2	3
Saccharomyces	....	....	....	1	1	....	2

isms, plates of a medium composed of a modified Detmer's solution solidified by the addition of 1.5 per cent agar were exposed on February 22 at altitudes ranging from 1,000 to 3,000 feet. These plates were brought into the laboratory, and incubated for a week under condition of moderately low temperature, high humidity, and continuous illumination provided by a 25-Watt bulb, but the results obtained were entirely negative.

ABUNDANCE OF THE VARIOUS TYPES OF ORGANISMS

At the time of exposure of each plate, records were made of altitude, length of the exposure, and speed of the plane. Counts of the number of bacterial and fungus colonies were made after an incubation period of three days, as previously stated. From this information, as a basis together with the area of the surface of the Petri dish (9.6 sq. inches, or 0.067 sq. feet) calculations were made of the number of organisms per cubic foot of air, for each plate exposed.

TABLE 3

The abundance of organisms at different times, in relation to the weather conditions

Date	Temp. F.°	Rel. humidity, %	Wind	Organisms per cubic foot	Bacteria colonies: % of total	Fungus colonies: % of total
Oct. 19	81	45	NNE 5	0.65	61.3	38.7
Oct. 26	74	27	S 12–13	0.95	88.7	11.3
Nov. 9	38	67	W 7	0.20	77.7	22.3
Dec. 6	42	45	NNW 16	0.52[a]	66.2	33.8
Jan. 25	56	37	WSW 8–9	0.27[a]	95.9	4.1
Feb. 22	52	36	WSW 2	0.14[a]	90.1	9.9

[a] Inasmuch as these three flights were made at higher altitudes than the first three, the figures given are for all exposures at 1,000–2,000 feet.

It must be borne in mind that the technique employed imposes certain limitations. The figures refer only to viable organisms capable of growth on the particular medium employed under aerobic conditions. Furthermore, the ground speed of the plane is open to considerable inaccuracy of measurement because wind direction and velocity were not taken into account.

The calculations from all seventy-six plates exposed, regardless of altitude, gave an average of 0.21 organisms per cubic foot of air. The maximum, of 1.19 organisms per cu. ft., was obtained on a plate exposed at 1,500 feet on October 26, while none was obtained on a plate exposed for thirty seconds at 6,000 feet on December 6.

The data concerning the abundance of organisms at various times are too voluminous for detailed presentation, but a condensed summary is included in table 3.

The data in the above table indicate fluctuations in the populations of microorganisms at the 1,000–2,000 foot levels varying from 0.14 to 0.95

organisms per cubic foot. It has been impossible to correlate these findings with the existing weather conditions. All flights were made on days in which no rain had fallen for several days previously, so that decreases in the populations due to this factor may be ruled out. The high counts obtained on October 26 are probably causally related to the combination of very dry air and a high wind, and it appears significant that the lowest counts were obtained on February 22, when the wind velocity was least. It is admitted, however, that the atmospheric conditions at a given altitude may be very different from those encountered at the ground level, and that a much larger number of observations would be required to yield results of decisive value.

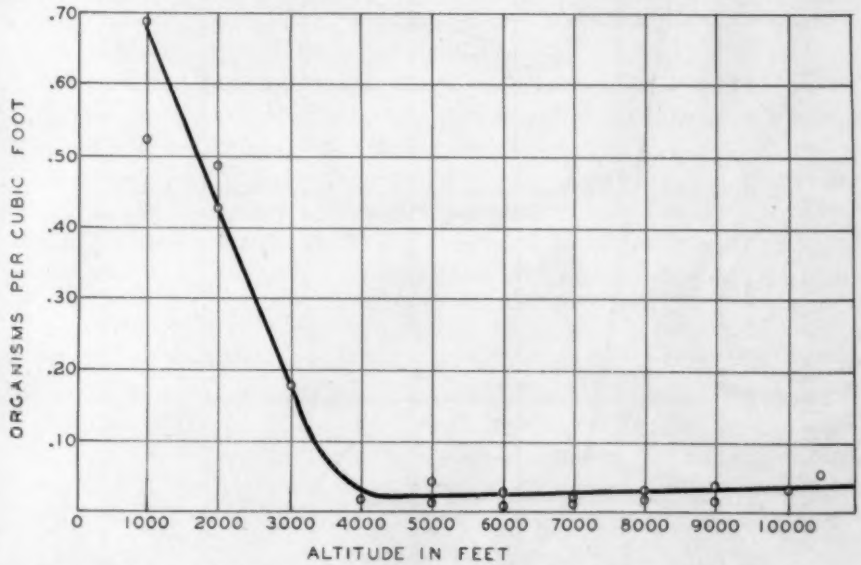

FIG. 1. The distribution of organisms at various altitudes over Nashville, Tenn., on Dec. 6, 1941.

The general decrease in concentration of organisms with increasing altitude is shown in the accompanying graph (fig. 1) based upon data gathered on the flight to 10,600 feet elevation. The entire series of exposures, on this particular flight was made at temperatures below freezing, with a minimum of 22° F. being recorded at 5,000 feet. The concentration of organisms fell sharply between 1,000 and 4,000 feet, above which altitude a small but rather constant population was found.

Proctor (1934) has presented evidence for the existence of "biological strata" in which microorganisms may be present in higher quantities than in the air above or that below the given level, due to vertically localized weather conditions and air movements. This finding is borne out by results obtained on January 25, in which much higher counts were obtained at the

3,000–4,000 foot levels than at either 2,000 or 5,000 feet (fig. 2). The factors responsible for this condition are as yet little understood, and must await further experimentation.

According to Proctor (1934), "the biological population of the upper air is probably an ever-changing one, never constant either in type or in distribution, due to the many factors which may interact at the same time."

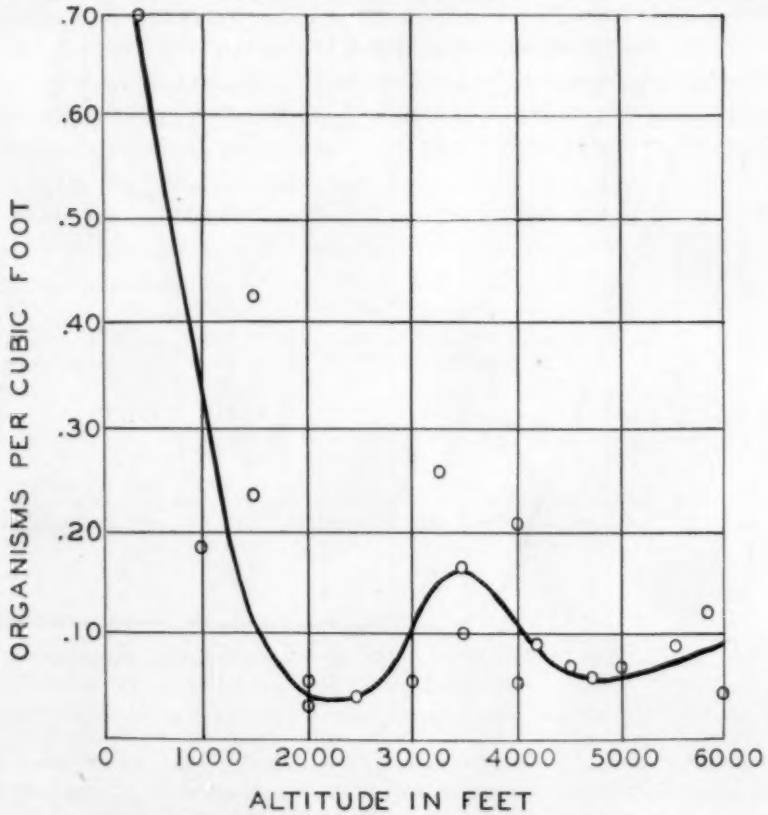

FIG. 2. The distribution of organisms at various altitudes over Nashville, Tenn., on Jan. 25, 1942. Note the higher counts between 3,000 and 4,000 feet.

In the present experiments bacteria were always more abundant than fungus spores, and composed from 61.3 to 95.9 per cent of the total microflora of the air. The proportion of fungi varies from day to day between 4.1 and 38.7 per cent of the total. Yeasts and actinomycetes were never abundant, and together they make up somewhat less than 1 per cent of the microorganisms of the air.

SUMMARY

Studies of the microbiology of the air over Nashville, Tennessee, were

made by exposing Petri dishes containing nutrient agar from airplanes. Twenty-nine different species of bacteria, including species of *Achromobacter, Bacillus, Flavobacterium, Micrococcus, Pseudomonas, Sarcina,* and *Serratia,* were identified from the plates exposed. Spore-forming rods and cocci were about equally abundant, with non-spore-forming rods being present in lesser concentrations.

Sixteen genera of fungi, including species of *Mucor, Chaetomium, Acladium, Aspergillus, Cephalothecium, Oospora, Penicillium, Scopulariopsis, Verticillium, Alternaria, Brachysporium, Helminthosporium, Hormodendrum, Macrosporium, Fusarium,* and *Plenozythia* were found. *Alternaria, Hormodendrum,* and *Fusarium* species appear to be most abundant and to be consistently present.

Quantitative data were secured indicating an overall average of 0.21 organisms per cubic foot of air. This concentration of organisms is subject to wide variation, induced by a number of factors.

Bacteria were the most abundant group of microorganisms occurring in the upper air, composing 61.3 to 95.9 per cent of the total. The proportion of fungi varied from 4.1 to 38.7 per cent of the total number of microorganisms. Yeasts and actinomycetes were also present in small quantities.

The writer acknowledges with thanks the assistance rendered by Dr. F. A. Wolf, who has identified the bacteria collected during this work, and has criticized the manuscript. He is also deeply appreciative of the courteous cooperation of Dr. N. F. Conant, Dr. V. M. Cutter, Jr., Dr. D. H. Linder, and Dr. C. D. Sherbakoff in identifying certain of the fungus cultures. Assistance in the laboratory work involved in this study was provided by a grant-in-aid from the Graduate School of Vanderbilt University.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 15–25 JANUARY, 1943

THE STRUCTURE AND DEVELOPMENT OF THE SHOOT APEX OF EPHEDRA ALTISSIMA DESF.

ERNEST M. GIFFORD

INTRODUCTION

Although the structure of the shoot apex of *Ephedra altissima* has been previously studied (Schmitz 1874; Groom 1885; Koch 1891), methods of modern micro-technique permit a more precise interpretation of the anatomical features of shoot apices. Recent work (Korody 1937; Foster 1938, 1939, 1940, 1941; Johnson 1939; Cross 1939, 1941, 1942) shows a definite trend in the complexity of the apices of gymnosperms from the seemingly primitive types of apices of the Cycadaceae to the more advanced type of the Taxodiaceae. Cross (1939) has shown the apex of *Taxodium* to approach the structural condition characteristic of the angiosperms. There is, however, a definite gap between the two which might be suspected to be bridged by the apex-type or types of the Gnetales. The present study shows that *Ephedra altissima* represents such an intergrading form.

MATERIALS AND METHODS

Apices were obtained from a single plant growing on the campus of the University of California and from plants growing on the Anson S. Blake estate in Berkeley, California. Buds were collected at several intervals between January, 1941, and March, 1941, and in January, 1942. The apices were killed and fixed in three fixatives primarily, *viz.:* (1) Zirkle's basic fixative ($CuCrO_7$, 2.5 g.; CuO, 0.05 g.; $CuSO_4$, 1.0 g.; H_2O, 100 cc.). (2) Corrosive sublimate, 3.0 g.; butyric acid, 3 cc.; 70% alcohol, 100 cc. (3) Chromic acid (0.5 g.; H_2O, 100 cc.)—neutral formalin (21 cc. commercial; H_2O, 100 cc.); mix equal parts when using. The latter fixative gave the best results. The material was dehydrated, cleared in xylene, and embedded in paraffin according to the method outlined by Ball (1941). Serial longitudinal and transverse sections were cut from 5–8 μ in thickness, stained with tannic acid-iron chloride, and counterstained with safranin (Foster 1934). Drawings were made with a 7.5× ocular and a 54× oil-immersion objective.

GENERAL FEATURES OF THE SHOOT SYSTEM

Two types of shoots exist in *Ephedra altissima:* (1) a large type which constitutes most of the shoot system, and (2) a smaller, shorter-lived deciduous type which develops from the nodes of the larger shoots. At each node of the first and more vigorous type, there are three leaves in whose axils the second type of shoot arises. The latter possesses decussate phyllotaxis.

The first indications of growth in the spring appear in the large type of shoot, whose rapid growth is accompanied by the development of the axillary, small shoots.

The large or permanent shoots ultimately cease growth but during the growth period numerous axillary permanent shoots develop at older nodes. The present paper does not deal with the origin of these shoots. Possibly the initiation of these shoots is similar to that of the "pseudo-endogenous" buds of *Taxodium* described by Cross (1939). In the present work only the structure of the apices of the two types of shoots are considered.

In the present investigation it has been found that the average diameter of the shoot apex of 40 vigorous permanent shoots is 180 μ while the height is 80 μ. The apex of the smaller shoot possessing decussate phyllotaxis has an average diameter (30 apices measured) of about 110 μ while 75 μ is common for height.

REVIEW OF LITERATURE

After the formulation of the concept of "apical cell" by Nägeli (1878) many subsequent workers attempted to find in all groups of plants such an apical cell from which all subsequent tissues could be traced. Nägeli was rightfully impressed with the regularity and sequence of cell divisions in the apical cell of Thallophytes and certain Bryophytes and thought that no fundamental difference would be found in the organization of apical tissues in both lower and higher groups of plants.

In attempting to prove the doctrine of Nägeli, Dingler (1882, 1886) stated that it was possible in *Ephedra monostachya* (1882) to observe an apical cell (*Scheitelzelle*), which was prismatic or tetrahedral in form. Korschelt (1884) using *E. vulgaris* agreed with Dingler that an apical cell occurred in this genus as well as in other gymnosperms. Schwendener (1879, 1885) concluded from his studies that the shoot apex of certain gymnosperms is crowned by a group of four juxtaposed apical initials. However, the apical meristem of *Ephedra monostachya* did not have the tetrad of apical cells but possessed an irregular group of initials. As late as 1890, Douliot emphasized his firm opinion that "apical-cell segments" exist in gymnosperms and illustrated his belief with schematic diagrams and elaborate drawings of the cell net.

After the announcement of the histogen theory by Hanstein in 1868, many workers labored to disprove the contentions of the champions of the apical cell theory and to show the universality of histogens. Karsten (see Koch 1891) adopted the histogen theory and maintained that histogens were present in *E. altissima*. According to Schmitz (1874), however, the dermatogen of *E. altissima*, though well defined, was occasionally interrupted by periclinal divisions; and the inner tissue exhibited in no way an organization into a definite central plerome and surrounding periblem. In another

species, *E. campylopoda*, Strasburger (1872) stated that a continuous protoderm was usually present but that the separation of periblem and plerome is hardly ever present. This observation was confirmed by Groom (1885) in *E. altissima*. The next important work was by Koch (1891) who described for the apex of *E. altissima* an inner core, forming the pith, and an outer "Hullgewebe," the latter being more meristematic in nature. In confirmation of his own observations Koch (1891) pointed to the work of Sanio (1863) who found, besides the epidermis, in the apex of *E. monostachya* a "pith" composed of a few cells and an outer somewhat thinner-walled tissue. Koch was the first to present a precise and accurate description of the evident cytological zonation in the shoot apex of *Ephedra altissima* and other gymnosperms.

THE SURFACE LAYER

The vigorous apices of both types of shoots are characterized generally by a discrete surface layer which may well be termed the tunica and will be referred to as such in subsequent discussion. Only one exception to this condition has been found and will be considered later. The tissue other than the tunica will be referred to as the corpus (Schmidt 1924).

The usual configuration of the surface layer in the permanent shoots is that of a continuous layer (figs. 1, 3–11), giving rise to the future epidermis. The cells of the tunica often vary in size, structure, and staining qualities; however, in all apices the tunica is uniseriate.

While the above condition is characteristic of the surface layer of the apex, one exception from a series of 40 buds has been found (fig. 2). This figure depicts an apex in which a periclinal division followed by an anticlinal one, has recently taken place in a cell of the tunica. Thus a group of three genetically related cells has been produced. The cell of the tunica immediately to the left of this group has enlarged greatly and may have been on the verge of a periclinal division at the time of fixation. Such a temporary enlargement of a cell of the apex probably lead some of the earlier workers (Dingler 1882; Korschelt 1884; Douliot 1890) to assume and describe the presence of an apical cell. This apex represents the only clear-cut example of such a division, while other seemingly similar cases fail to show such a condition upon critical examination. It is also interesting to note that this bud showed very vigorous growth. This observation agrees with that of Strasburger (1872) who stated that in vigorously growing vegetative apices of *E. campylopoda* the uppermost dermatogen cell may divide transversely (periclinally). The discovery of this example suggests that such divisions may occur from time to time in many vigorous vegetative shoot apices of *E. altissima*. The sub-apical divisions of these cells resulting from the periclinal divisions augment the corpus. The apical and sub-apical cells, indicated by means of nuclei in figure 2, together as a group resemble the apical

initial group of *Ginkgo biloba* described by Foster (1938). Apparently the formation of such a group of apical initials and their derivatives is associated with vigorous growth and may occur during a certain phase in the development of a particular shoot apex.

THE SUB-APICAL REGION OF THE SHOOT APEX

Directly beneath the tunica layer of the apical meristem lies a region that occupies the focus of meristematic activity. This region may be termed the *sub-apical initiation zone*, and the cells composing it, *sub-apical initials* (figs. 1–11). The latter are similar in position and function, but not in size or structure to the "central mother cells" of *Ginkgo* (Foster 1938). The sub-apical initials produce a *central tissue zone* (fig. 3), precursor of the pith, which, in very vigorous shoots, is characterized by highly vacuolate dividing cells having the appearance of a very sluggish "rib meristem" (Schuepp 1926). The cells of the central tissue zone exhibit polarized growth and progressive elongation. The sub-apical initiation zone gives rise also to the cells of the *peripheral zone*. In striking contrast to the vacuolate dividing cells of the pith-forming region the peripheral cells are rich in protoplasm (figs. 4, 5, 7, 8), and stain deeply; cell divisions rather than elongation of the individual cells dominate in this region. Cortex, leaf primordia, and vascular tissue are ultimately produced from the peripheral zone.

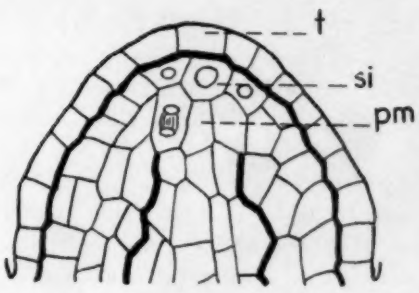
In the majority of the permanent shoot apices studied it was possible to distinguish one tier of sub-apical initials which seemingly were engaged in anticlinal divisions, contributing cells to the peripheral flanks (figs. 3, 4, 5, 7). Directly beneath this group of initials are found the *pith mother cells* (figs. 1, 3, 4, 5, 8). The configuration as described above does not always exist, that is, an upper group of initials dividing only anticlinally. Figure 6 illustrates a periclinal division in a centrally located initial. The same photomicrograph shows how difficult it is to decide which initials give rise to the cells of the peripheral flanks and which contribute to the central zone.

While the configuration as described above is common for many permanent shoot apices, it has been found that the sub-apical initiation zone may consist of two or more tiers of cells engaged primarily in anticlinal divisions (figs. 3, 8).

In contrast the apices of the deciduous shoots show no orderly arrangement of the cells of the sub-apical zone. A definite cap of initials in the sub-

Explanation of figures 1–3

FIG. 1. Median longisection of the shoot apex of an early expanding permanent shoot; *t*, tunica; *si*, sub-apical initials; *pm*, pith mother cells. ×465. FIG. 2. Median longisection of the shoot apex of a vigorous permanent shoot showing evidence of a periclinal division in the tunica. Note also the enlarged cell of the tunica to the left; *ai*, apical initial. ×465. FIG. 3. Median longisection of the shoot apex of a permanent shoot during maximal growth; *pz*, peripheral zone; *t*, tunica; *cz*, central zone. ×465.



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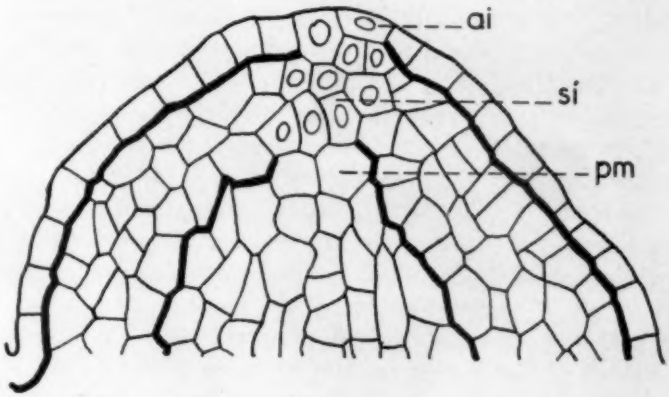

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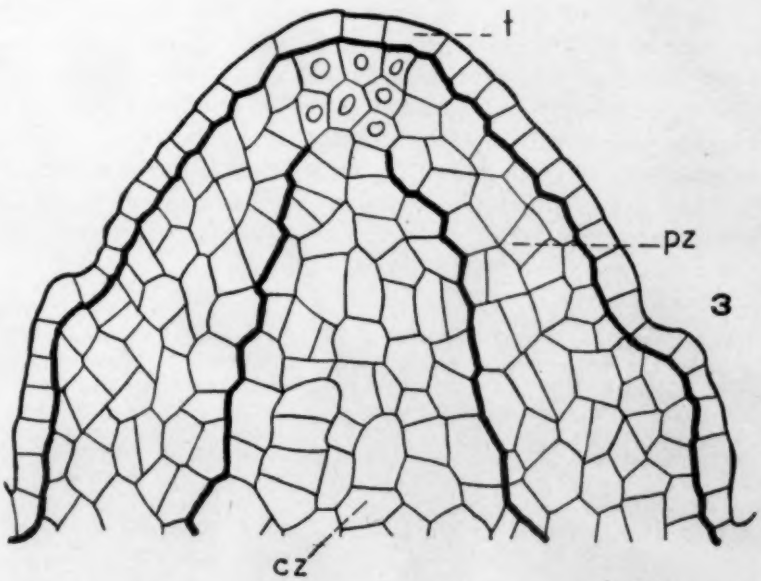

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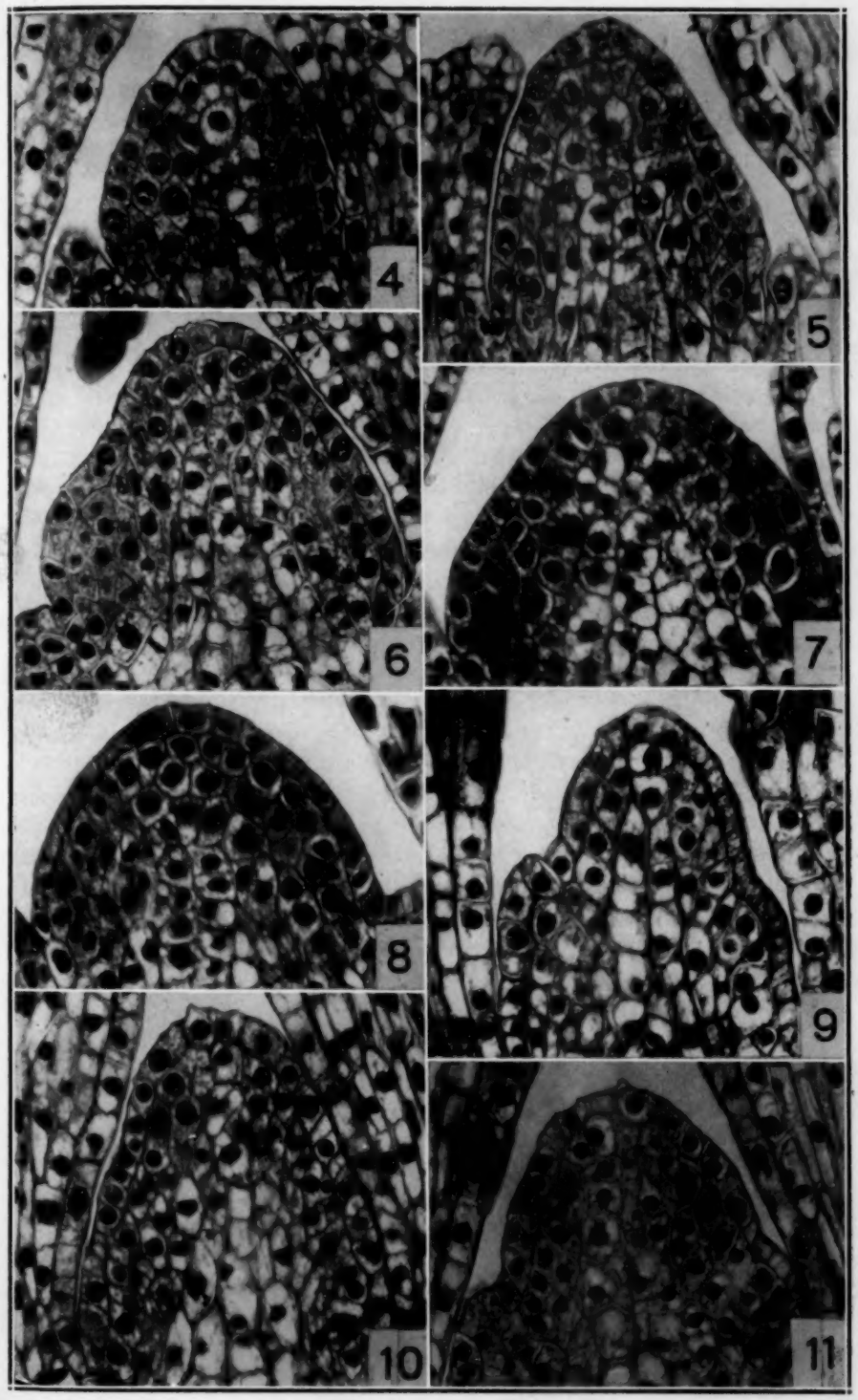
apical zone is hardly ever present. The apices seem to possess a small group of initials which divide periclinally as well as anticlinally. In many apices (figs. 10, 11) the cells of the pith-forming region, or central zone, can be traced up to a cell of the first sub-apical tier of initials directly beneath the tunica.

In some shoots of both types, particularly in vigorous permanent shoots, the cells of the central zone are very regularly arranged in vertical rows. They have the appearance of a true "rib meristem" (figs. 7, 8). Frequently this arrangement is confused by subsequent periclinal and oblique divisions and irregular enlargement of the derivatives of the pith mother cells (figs. 1, 2, 3, 6, 7). This condition is similar to that observed in the shoot apices of *Taxodium distichum* (Cross 1939) and *Cunninghamia lanceolata* (Cross 1941); but in contrast to the clearly defined rib meristem zone in *Ginkgo* and *Dioon* (Foster 1938, 1941). The pith mother cells as well as their derivatives are vacuolate, a feature common to many conifers (Koch 1891, Korody 1937, Cross 1939). Derivatives of the sub-apical initial cells that constitute the meristematic flanks undergo subsequent periclinal and oblique divisions (figs. 1, 2, 3, 5, 7, 8) as well as anticlinal divisions, and no clear stratification as observed in the tunica can be found. These divisions enlarge this zone considerably at the level of a newly forming leaf primordium (figs. 3, 6, 7).

In summary, it appears that the sub-apical region of the shoot apices of *Ephedra altissima* consist in general of three zones characterized by size of cells, structural and staining qualities, and type of division that predominates. Directly beneath the tunica there is a highly embryonic region termed the *initiation zone* from which is produced by anticlinal divisions: (1) *the meristematic flanks*, and by periclinal divisions (2) *the pith mother cells* which give rise in turn to cells constituting the *central zone* or precursor of the pith. The pith mother cells do not maintain their position indefinitely but are ultimately incorporated in the pith; this is followed by a new production of pith mother cells from the tier or tiers of sub-apical initials

Explanation of figures 4–11

FIG. 4. Longisection of shoot apex of an early expanding permanent or large shoot showing a clearly delimited tunica and sub-apical initial group. ×405. FIG. 5. Longisection of shoot apex of a permanent shoot in nearly the same growth phase as fig. 1. ×405. FIG. 6. Longisection of shoot apex of a permanent shoot showing a periclinal division in a sub-apical initial cell directly beneath the tunica. ×405. FIG. 7. Longisection of shoot apex of a permanent shoot in maximal growth. Note the great width of the apex. ×405. FIG. 8. Longisection of a permanent shoot apex in maximal growth illustrating the well defined tunica and stratified nature of the sub-apical initiation zone. ×405. FIG. 9. Longisection of a permanent shoot apex near the cessation of growth. Note the highly vacuolate condition of all the cells. ×405. FIG. 10. Longisection of an apex of the small type of shoot showing the discrete tunica. ×405. FIG. 11. Longisection of the shoot apex of the small type of shoot showing the extent of a row of pith forming cells. ×405.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directly beneath the tunica. The initiation zone must be regarded as a dynamic and changing entity, governed undoubtedly by volume-surface relations.

SEASONAL VARIATION IN THE STRUCTURE OF THE SHOOT APEX

It was possible on the basis of this investigation of the shoot apex to construct a series showing the changes in structure and configuration of the apical meristem during the course of development of a permanent shoot apex.

Figures 4–9 represent a developmental series beginning with the initiation of growth, through maximal development, and ending with the cessation of growth.

It has been found that in early expanding shoots the apex is relatively small, yet shows discrete tunica and corpus regions (figs. 1, 4, 5). As growth proceeds, the apex becomes more voluminous because of the tendency toward an increase in the width of the central zone or pith-forming region. At a still later period the peripheral zone becomes more stratified (figs. 3, 8) and the central zone assumes in many apices the configuration of a rib meristem. The arrangement of the cells of the sub-apical zone in tiers gives a massive appearance to the apical meristem. It is during this vigorous growth phase that the one exception to the continuous uniseriate tunica was observed. During this period periclinal divisions probably occur in the tunica from time to time in any one particular apex. At the same time the central zone increases decidedly in width (fig. 2) and a rapidity of division of the derivatives of the pith mother cells follows. As growth begins to decline the reverse of the above sequence of events takes place, the configuration becoming as in figure 9. The initiation zone is reduced to a few highly vacuolate cells which sluggishly continue to produce the two zones. The pith becomes narrow and the elongation of its cells dominates over cell division. The cells of the peripheral flanks likewise increase in size and tend to become more vacuolate in nature.

DISCUSSION

The present study does not support the view that *Ephedra altissima* has has an apical cell. In only one of the apices studied was there an indication of a cell that could be interpreted as an apical cell (fig. 2). Possibly the temporary enlargement in depth of a single cell at the apex as is seen in this figure lead Douliot, Dingler and Korschelt to assume the presence of a single apical cell in the terminal meristem of *Ephedra* as well as in the apices of other gymnosperms. The observations of the writer, however, agree in some respects with certain of the earlier investigations. Figure 4 illustrates a condition resembling that described by Karsten (see Koch 1891). According to Karsten the "plerome" ended in one cell and the dermatogen and

"periblem" each consisted of one layer of cells over the apex. That "plerome" and "periblem" may not be sharply defined in *Ephedra altissima,* as emphasized by Schmitz (1874) and Groom (1885), is well illustrated in figs. 2, 6, 11. The type with a central tissue surrounded by a "Hullgewebe" as described by Koch is found in figs. 2, 3, 7, 8.

In recent years certain workers (Korody 1937, Härtel 1938) have attempted to homologize the corpus of the angiospermous apical meristem to the entire shoot apex of certain primitive vascular plants such as *Lycopodium.* A critical examination of this viewpoint has already been undertaken by Foster (1938, 1939b) and Cross (1939, 1941, 1942). The former (1938) came to the conclusion that the apex cannot be looked upon in such a light because such a concept is "based upon too rigid a morphological distinction." In Foster's opinion the tunica and corpus represent "interdependent growth zones" and as such one cannot exist without the other. It is also important to emphasize that while a virtually "stabile" tunica occurs in *Ephedra altissima,* the peripheral zone is only vaguely stratified. "From this standpoint, the evolution of the angiospermous type of shoot apex may have involved an ever increasing emphasis upon surface growth *throughout* the apical and peripheral regions of the meristem." (Foster 1939b). Accepting these two postulates we are led to the concept that through phylogeny there has been an increased stimulus to "surface growth" bringing about the tunica-corpus condition as typified by angiosperms.

Thus a series can be made from the massive condition as exhibited by *Cycas revoluta* (Foster 1939a, 1940) to the more refined types which exhibit to greater or lesser degree the tunica-corpus condition. Some very interesting points of a comparative nature have been brought out by Foster (1941b), who points out that the *Abies venusta* type of apex is common in the conifers; that is, the type characterized by the presence of an outer peripheral zone composed of actively-dividing cells from which arise the epidermis, cortex, leaf primordia, and provascular tissue; and an inner core or central-zone, the precursor of the pith. These zones arise from an ill-defined sub-apical zone which in turn has arisen from derivatives of apical initials. *Araucaria bidwilli* on the other hand has a more regular surface layer. Recently Cross (1939) has found a clearly delimited uniseriate tunica and central corpus in the permanent shoots of *Taxodium distichum.* A similar condition was found by the same author (1941) for the shoot apex of *Cryptomeria japonica;* however, more periclinal divisions were observed in the surface cells of the apex of this plant. In the writer's opinion the condition exhibited by *Ephedra altissima* represents a still further advance in the attainment of the two morphologically independent zones, tunica and corpus.

SUMMARY

The cyto-histological features of the shoot apices of the two types of shoots found in *Ephedra altissima* are described. The apical meristems of all shoots investigated except one are characterized by a uniseriate tunica and a corpus region. One vigorous permanent shoot apex exhibited a periclinal division in the tunica at the summit of the apex.

The sub-apical portion of the apical meristem consists of a sub-apical initiation zone which is the focus of growth and may show a regularity of structure at times. This region gives rise to a central tissue zone and a peripheral tissue zone, each characterized by specific characters. The initiation zone produces "pith mother cells" which divide for a period of time but ultimately are replaced by new pith mother cells from the initiation zone. The peripheral zone increases in width by periclinal divisions as well as anticlinal divisions. Derivatives of this region form the cortex, leaf primordia, and provascular tissue while the epidermis is derived from the tunica.

A comparison of the structure of the shoot apices of *Ephedra altissima* with that of other gymnosperms, leads to a conclusion that the apical meristems of this species represent an advanced condition in this group of plants.

The writer is grateful to Dr. A. S. Foster for his guidance during the research. Thanks are due also to Mr. Louis Erickson for assistance in preparation of the photomicrographs and to Dr. K. Esau who assisted in the preparation of the manuscript.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 26–33 JANUARY, 1943

POLYPLOIDY IN SEDUM PULCHELLUM—I. CYTOGEOGRAPHY[1]

J. T. BALDWIN, JR.

This paper presents the chromosome numbers and geographic occurrence of three polyploid races of *Sedum pulchellum* Michx. as revealed by routine cytological analysis of the species at representative localities in its distributional area.

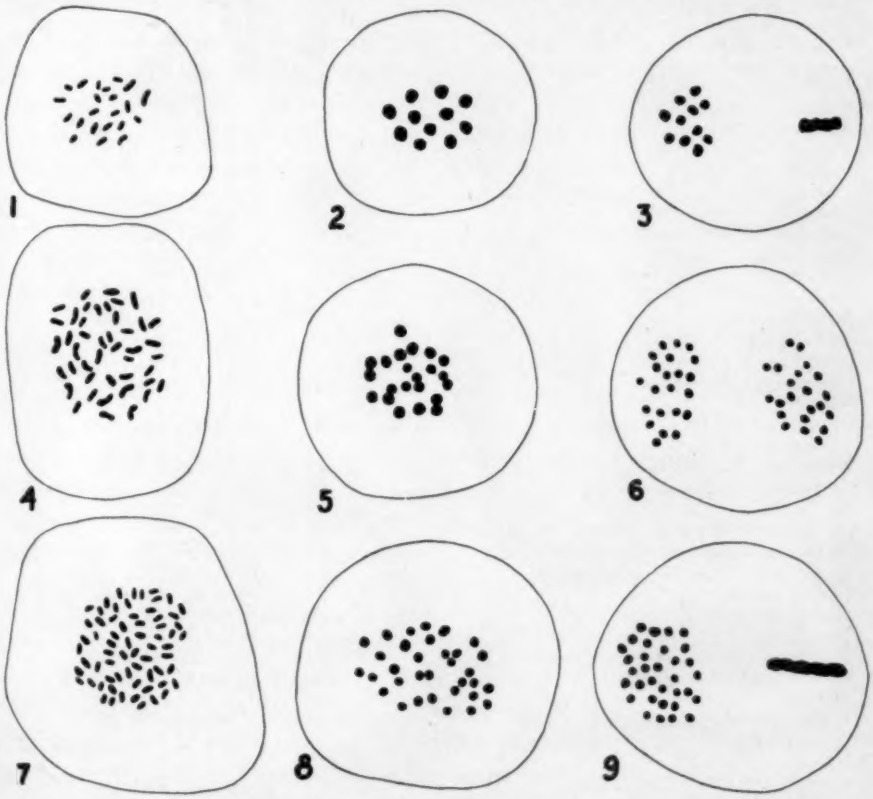
Michaux (1803) described *S. pulchellum* from "circa *Knoxville*," with no mention of the life-length of the plant. From this record Pursh (1814), in spite of having seen neither living nor dead specimens, indicated the species to be perennial. The writer knows the plant throughout its geographic range only as a winter annual, white- or pink-flowered. Wherry (1934), however, reviewed the history of a horticultural perennial of unknown origin that has long been identified with the above species. Nuttall (1818) confused *S. pulchellum* with a perennial later designated *S. nevii* Gray, and under this latter name, since 1858, two perennial sedums of the Appalachian Mountains have been passing (Baldwin 1942a). Torrey and Gray (1840) questioned the perenniality of *S. pulchellum* but accorded it a range which shows that in their concept of the species they incorporated the two perennials of the *S. nevii* group. The reason for the confusion (which continues up to the present) of the identity, range, and life-length of these plants lies in the fact that the juvenile stages of *S. pulchellum*—lasting from fall until spring, when flower-bearing stems are produced, spatulate leaves are lost, and linear, subterete leaves are developed—that these stages strongly resemble the nonflowering plants of the *S. nevii* aggregate.

Plants and/or seed of *S. pulchellum* from forty stations typical of the specific range, seed from four herbarium sheets in the Field Museum, and plants and seed from a huge, self-perpetuating population at The Blandy Experimental Farm in Virginia have supplied material for cytological study (see table 1). Plants and seedlings were grown in the University of Michigan Botanical Gardens. Chromosome counts for the forty-five collections were made from aceto-carmine smears of roots and leaves, and, in a few cases, from Nawaschin-fixed, crystal-violet-stained sections of roots; also, for certain collections of each chromosome-number race, gametic counts were made from aceto-carmine smears of pollen mother-cells.

[1] Paper from the Department of Botany of the University of Michigan, No. 802. Supported by the Faculty Research Fund, Project No. 569.

Publication of the illustrations was assisted by the Lucien M. Underwood Memorial Fund.

A polyploid series was established for the species: twenty-six collections were diploid—$2n = 22$, $n = 11$ (figs. 1–3); sixteen, tetraploid—$2n = 44$, $n = 22$ (figs. 4–6); three, hexaploid—$2n = 66$, $n = 33$ (figs. 7–9). Multivalent associations characteristic of high polyploids with small chromosomes are usually present during meiosis of the tetraploid and hexaploid plants. This doubtless accounts for the existence of atypical plants with $2n$-numbers of



FIGS. 1–9. Chromosomes of *Sedum pulchellum* at mitotic and meiotic (I and II) metaphases. FIGS. 1–3. Diploid: $2n = 22$, $n = 11$. FIGS. 4–6. Tetraploid: $2n = 44$, $n = 22$. FIGS. 7–9. Hexaploid: $2n = 66$, $n = 33$. All, ca. $\times$ 1085, from smears: relative sizes of cells are not strictly accurate; cell outlines in figs. 1, 2, and 4 were selected to accompany the metaphases drawn.

64 and 72 as found by the writer in the population at Blandy Farm. At first meiotic metaphase of tetraploid and hexaploid plants the chromosome number is difficult to determine because of the grouped associations—which may often be secondary rather than primary, but at second metaphase counting is comparatively easy. All the plants are highly self-fertile.

The accompanying map (fig. 10) shows the distribution of the species

TABLE 1

Collections of Sedum pulchellum for which chromosome numbers were determined

Source	2*n*-number	Collector
Missouri		
Polk Co.: Burns	22	*J. A. Steyermark 27232*[a]
Camden Co.: Bannister	22	*J. A. Steyermark 6886*
Cedar Co.: Tilley	22	*J. A. Steyermark 27465*
Moniteau Co.: Jamestown	22	*J. A. Steyermark 24826*
Stone Co.: Galena	22	B & G[b]
Jasper Co.: Joplin	22	B & G
McDonald Co.: Noel	22	B & G
Arkansas		
Lawrence Co.: Imboden	22	B & G
Lawrence Co.: Jesup	22	B & G
Carroll Co.: Busch	22	B & G
Carroll Co.: Eureka Springs	22	B & G
Sharp Co.: Shelbyville	22	B & G
Independence Co.: Batesville	22	B & G
Boone Co.: Francis	22	B & G
Washington Co.: Fayetteville	22	B & G
Benton Co.:	22	B, G & D. M. Moore
Benton Co.:	22	D. M. Moore
Pulaski Co.: Little Rock	22	Delzie Demaree
Oklahoma		
Carter Co.: Ardmore	22	Milton Hopkins
Alabama		
Madison Co.: Monte Sano	22	R. M. Harper
Tennessee		
Knox Co.: Knoxville	22	J. T. Baldwin, Jr.
Jackson Co.: Roaring River	22	B & G
Bedford Co.: Shelbyville	22	B & G
Rutherford Co.: near Bedford County line	22	B & G
Rutherford Co.: Murfreesboro	22	B, S & H[c]
Sumner Co.: near Goodlettsville	44	B, S & H
Cheatham Co.:	44	Jean M. Campbell
Davidson Co.: Nashville	22	B, S & H
Davidson Co.: 14 miles w. Nashville	44	B, S & H
Davidson Co.: 12 miles s. Nashville	44	Jean M. Campbell
Davidson Co.: Nashville	66	B, S & H
Wilson Co.: Lebanon	66	B, S & H
Wilson Co.: Lebanon	66	L. M. Dickerson[d]
Wilson Co.: Cedar of Lebanon State Park	44	B, S & H
Kentucky		
Fayette Co.: Elk Lick Falls	44	Mary E. Wharton
Fayette Co.: Raven Creek	44	B, S & H
Anderson Co.: Tyrone Bridge	44	B, S & H
Woodford Co.: Camp Offut	44	B, S & H
Mercer Co.: Shaker Town	44	B, S & H
Clark Co.: Lower Howard Creek	44	B, S & H
Jessamine Co.: Wilmore	44	H. T. Shacklette
Caldwell Co.: Princeton	44	A. M. Harvill
Simpson Co.:	44	B, S & H
Illinois		
Union Co.: Cobden	44	B & G
Johnson Co.: Sanburn	44	B & G

[a] Seed from herbarium specimen in Field Museum.
[b] J. T. Baldwin, Jr., and Walton C. Gregory.
[c] J. T. Baldwin, Jr., H. T. Shacklette, and A. M. Harvill.
[d] Transplanted to The Blandy Experimental Farm in Virginia about 1930.

and of its races as known to the writer by the collections listed in table 1, by specimens in certain herbaria,[2] and by county-collection records of Palmer and Steyermark (1935) for Missouri. The species occurs from Dade County, Georgia, and Madison County, Alabama, through Tennessee and Kentucky to Union and Johnson counties, Illinois, and, west of the Mississippi River, through much of Missouri and Arkansas into Kansas, Oklahoma and Texas. (Steyermark (1942) has written an extended note on the occurrence of *S. pulchellum* in Missouri.) The present cytological data indicate that only the diploid is found in the western and southern parts of the specific area, that only the tetraploid occurs from northern Tennessee through Kentucky and in Illinois, and that the hexaploid exists only in northern Tennessee in the region of contact between the other two races, being found, for example, on the grounds of Cumberland University at Lebanon, Tennessee. The diploid, and supposedly oldest, race is the most extensively distributed. It is logical to consider that the tetraploid arose from the diploid by chromosome doubling, and, similarly, the hexaploid from an inter-racial triploid. (One would not expect to find an annual established as a triploid: survival of an annual is normally dependent on regular meiosis.) The evidence is that the tetraploid moved northward, and, thus, into the only ecologically suitable territory[3] that was nearby and not already occupied by the species. To attempt, as yet, a statement of the direction of migration of the diploid is hazardous.

S. ternatum, the only other species of *Sedum* for which an intensive cytogeographic study has been made, is, with respect to the conditions just enumerated for *S. pulchellum,* quite different (Baldwin 1942b). It is perennial. Its races can maintain themselves vegetatively. Its diploid race is restricted to a limited area from which the tetraploid has spread radially throughout the specific range. A hexaploid race is known from one station, that being at the southern edge of the range of the species and near the tetraploid. A triploid is known from two places: in West Virginia where both the diploid and tetraploid have been found, and in North Carolina where both these other races might be expected to occur. But *S. ternatum* and *S. pulchellum* have this in common: the tetraploid race, once established, has in each species been more evolutionarily effective than the diploid; the tetraploid in both cases migrated into new territory. The direction of migration, as is generally true, was determined by the whereabouts of accessible and ecologically suitable territory. Tetraploid *S. ternatum* accordingly spread in all directions; tetraploid *S. pulchellum* went north.

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[2] United States National Herbarium, and herbaria of the Field Museum, the New York Botanical Garden, the University of Arkansas, the University of Tennessee, the University of Kentucky and the University of Michigan. It was a privilege to examine the specimens.

[3] *S. pulchellum* is found "most frequently on limestone, but also . . . on granitic and siliceous rocks" (Palmer and Steyermark 1935).

In the southeastern part of its geographic area *S. pulchellum* extends into the general range of true *S. nevii* Gray, which has 12 somatic, 6 gametic chromosomes (Baldwin 1942a). The *S. nevii* alliance, as stated above, is often confused with *S. pulchellum*. For example: Dr. R. M. Harper sent the writer living specimens of a sedum from Monte Sano, Madison County, Alabama; study showed it to be diploid *S. pulchellum*, but Doctor Harper (letter of February 19, 1941) wrote: "everybody who has passed on my Monte Sano

FIG. 10. Distribution of *Sedum pulchellum*.

plant so far has called it *S. nevii.*" And so identified one finds it in the herbaria (*R. M. Harper 3780*). In the western part of its area, from Missouri and Kansas to Texas, *S. pulchellum* overlaps the range of *S. nuttallianum* Raf., which has 20 somatic, 10 gametic chromosomes.[4] The dead, fruiting

[4] The writer (1940) reported *S. nuttallianum* from near Georgetown, Texas, to have these numbers. The somatic number has been corroborated by him for a collection made, in company with Doctors Walton C. Gregory and D. M. Moore, in Benton County, Arkansas, during the summer of 1941.

plants of this latter species, a yellow-flowered winter (?) annual, superficially resemble the fruiting stems of *S. pulchellum*. Of course they can be distinguished without difficulty, but they do look somewhat alike, and not infrequently they are confused in herbaria. The species sometimes grow together, for example, in Benton County, Arkansas. The suggestion comes to mind, then, that true *S. nevii* is an expression of a 6-chromosome tendency in evolution and *S. nuttallianum*, as Baldwin (1940) concluded, of a 5-chromosome tendency and that *S. pulchellum* arose as an amphidiploid result of the fusion of these two trends in the development of the genus. The one tendency dominates the characters of the juvenile plant and causes confusion with *S. nevii;* the other dominates the characters of the senescent and dead plant and causes resemblance to *S. nuttallianum*. Accordingly, *S. pulchellum* is to be interpreted as an amphidiploid that has undergone autopolyploidy to produce 44- (amphitetraploid) and 66- (amphihexaploid) chromosome races. This latter plant, with 33 gametic chromosomes, is a high-numbered annual. Müntzing (1936) studied statistically chromosome numbers in forty-eight genera that include species with different life lengths; *Sedum* is, obviously, such a genus. He found: "With regard to the annual and perennial series it is striking that *all* species with the haploid numbers ranging from 40 to 105 are perennial."

Under uniform conditions the chromosome-number races of *S. pulchellum* are morphologically different, but nevertheless, since the writer did most of his collecting of the species in the summer, when the plants were dead, he does not know whether or not the races can always be distinguished under field conditions. Judging by cytogeographic evidence alone, one would say that Michaux used the diploid as type material (from Knoxville) for this species and that John K. Small used the same race as type material (from Rising Fawn, Dade County, Georgia) for *S. vigilimontis*. This latter plant, as pointed out by Wherry (1935), is clearly referable to *S. pulchellum*. Fröderström (1935), in his monograph on the genus, recognized Small's species, with the qualification, however, that it is "perhaps but a local variety" of *S. pulchellum*. The late Doctor Jennison, on an herbarium sheet of *S. pulchellum* at the University of Tennessee (*H. M. Jennison 198*, Knoxville city limits, May 28, 1938), wrote: "approaching *S. vigilimontis* Small—the which I do not think is a good species—but only a variety." The writer found plants at this Knoxville station, which must be near the type locality for *S. pulchellum*, to be diploid. The judgment that Small's plant also belongs to the diploid race may be tested by measurement of the type and also by determination of the chromosome number of plants at Rising Fawn, Georgia. Torrey and Gray (1840) state that Nuttall gave a manuscript name, *S. linifolium*, to a form of *S. pulchellum* in Arkansas. Again, on cytogeographic data, one considers that the plant in question was probably diploid.

SUMMARY

Forty-five collections of *S. pulchellum*, from representative places in the specific area, were examined cytologically: twenty-six were diploid—$2n = 22$, $n = 11$; sixteen, tetraploid—$2n = 44$, $n = 22$; three, hexaploid—$2n = 66$, $n = 33$. Multivalent associations occur at meiosis in tetraploid and hexaploid plants. Some deviants from the $2n$-number of 66 were found.

The species is distributed from Missouri to Texas and from southern Illinois through Kentucky and Tennessee to Alabama and Georgia. The diploid is found west of the Mississippi River and in the southern part of the range. The tetraploid has moved from northern Tennessee into Kentucky and Illinois. The hexaploid is found in Tennessee where the diploid and tetraploid races meet. The cytogeographic situation in this species is quite different from that in *S. nevii*. The two species are alike, however, in that the tetraploid, once established, in each species has been more effective evolutionarily than the diploid: the tetraploid in both cases migrated into new territory.

S. pulchellum possibly arose as the amphidiploid result of the fusion of a 6-chromosome tendency, now exemplified by true *S. nevii*, with a 5-chromosome tendency, now exemplified by *S. nuttallianum*. This explanation accounts for the marked similarity—resulting in frequent taxonomic confusion—of the juvenile plants of *S. pulchellum* to nonflowering plants of *S. nevii*; it also explains the resemblance of the matured stages of *S. pulchellum* and *S. nuttallianum*, an annual within the area of *S. pulchellum*, which is likewise annual. Accordingly, *S. pulchellum* is to be interpreted as an amphidiploid that has undergone autopolyploidy.

The three chromosome-number races differ morphologically, but the cytogeographic data indicate that only the diploid has been used—by Michaux, Nuttall, and Small—as a basis for nomenclatorial designation of wild plants of this species.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 34–41 JANUARY, 1943

PLANT SUCCESSION ON ABANDONED FIELDS IN THE CENTRAL WISCONSIN SAND PLAIN AREA[1]

JOHN W. THOMSON, JR.

Juneau County, Wisconsin, is in the part of the central sand plain area which is the bed of Glacial Lake Wisconsin. Here the residual soil of the underlying Cambrian sandstone has been reworked by water to form extensive areas of the Plainfield sandy soil series. In the southeastern part of the county there are large areas of the Boone series of sandy soils which are residual from the Cambrian sandstone but have not been reworked. These soils were much cultivated in Juneau County after settlement, which began in the eighteen-fifties, but their low fertility and their aridity have caused their abandonment in this century. As part of a study of the prairie flora in the central sand plain of Wisconsin, the succession of plants on some of these abandoned fields was observed in Juneau County.

Funds making possible the field work for this study were supplied by the Alumni Research Foundation of the University of Wisconsin. The studies on the abandoned fields were begun during the summer of 1936 by Arthur Oehmcke and the writer and continued in 1937 and 1938 by the writer. Grateful acknowledgment is made to Professor N. C. Fassett of the University of Wisconsin for constant help and suggestions during the progress of this study. I am indebted to my wife, Olive S. Thomson, for assistance in the field and in the preparation of this paper. The generous hospitality of Mr. and Mrs. F. N. Hamerstrom, Jr., made available their home as a center of operations while the field work was in progress.

Information upon the dates of abandonment was supplied mainly by Mr. Leo Laski of Necedah and Mr. Knute Olsen of the Olsen store at Mather. Little information upon the date of last cultivation could be obtained from people living near abandoned fields. Their reluctance may in part be ascribed to the habit of some people in central Wisconsin of farming county land. When definitely dated fields were located which were on ground that was not too low and wet for the study of prairie plants, they were examined during the three successive years. A total of thirteen separate fields were observed during this period. The detailed data are not presented in this paper owing to the exigence of space but may be obtained by consulting the writer's thesis submitted to the University of Wisconsin under the title of "Dynamics of some prairie plants in central Wisconsin." The observations of changes within an individual field were checked against fields of varying

[1] Part of a thesis submitted in partial fulfilment of the requirements for the degree of Ph.D. at the University of Wisconsin, 1939.

ages and the result expressed in the chart, figure 1. On this chart the vertical lines represent the observed comparative abundance of the species; and the dotted lines represent the probable curve of frequency of each species.

DISCUSSION OF THE SUCCESSION ON ABANDONED FIELDS

Field work on the abandoned fields in 1937 and 1938 substantiated the observations made in 1936,[2] although many of the fields had again been put under cultivation and observation on them terminated. The rapid succession or changes in the flora during the first few years is very marked and later changes occur but slowly. While these observations were made on land which had been under cultivation for several years and then abandoned, Mr. F. N. Hamerstrom, Jr., informed the writer that the succession which he had observed on plots which were plowed and then allowed to lie fallow with neither cultivation nor manuring, does not agree in its details with the observations noted here. He suggests that the early dominance of ragweed which we observed may be due to the manuring of cultivated fields. In support of this suggestion is an observation made by Mr. Wallace Grange on his property near Babcock, Wood County, in 1938. Here a ditch bank containing much organic matter in the form of peat was burned over and in the burned area arose a dense stand of *Ambrosia artemisiifolia*. Possibly the early dominance of this ragweed in the cultivated fields is dependent upon the presence of considerable organic matter.

The flora which becomes established in any given field will vary, depending on a number of factors including the ability of the plants to produce seed and to secure dispersion of the seed, the nearness of the field to a source of seed and the ecological condition of the field. The occurrence of some of the more conservative prairie plants such as *Desmodium illinoense* on some of the fields is dependent on the proximity of a prairie relic which provided a source of seed. The other plants involved in the succession are dependent on the same set of factors. While individual fields will thus vary somewhat in the plants which are established upon them, the discussion which follows embodies the generalized story of the succession.

In the fields which have been abandoned for but one year, the flora is much the same as during cultivation. There is an abundance of ragweed (*Ambrosia artemisiifolia*) and sandbur (*Cenchrus pauciflorus*). Canada Fleabane (*Erigeron canadensis*) is often very common. Of lesser importance is a large group of American weeds of southern distribution. These include *Mollugo verticillata, Leptoloma cognatum, Lepidium apetalum, Oenothera rhombipetala, Oenothera biennis, Panicum albemarlense,* and *Helianthus occidentalis*. A few European weeds may also become established, including

[2] **Thomson, J. W., Jr.** 1937. Dynamics of some prairie plants in Juneau County, Wisconsin. Unpublished thesis for the degree of M.A., Univ. Wis.

Setaria lutescens, *Euphorbia maculata*, *Polygonum convolvulus*, and *Rumex acetosella*. Individual plants of a few prairie species may enter the fields during the first year. Among those observed are *Euphorbia corollata*, which at times may even be common, *Andropogon furcatus*, and *Andropogon*

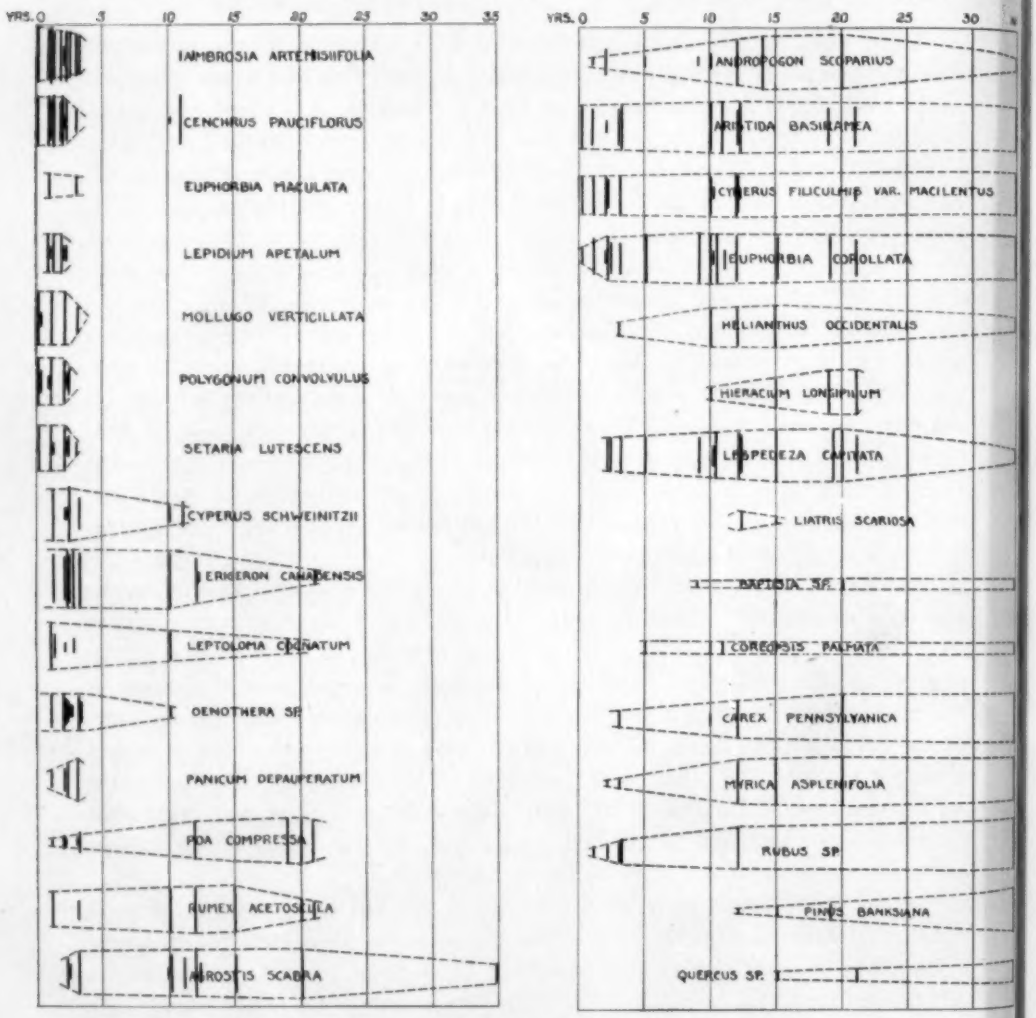


FIG. 1. Frequency of various species in abandoned fields.

scoparius. The prairie plants, however, do not attain any prominence in the early years; it is only at from nine to ten years after abandonment that they become important and they appear to reach a maximum in about fifteen years and thence show a slow decline until thirty-seven years, the age of the oldest field observed.

During the second year after the field is abandoned there is little change

to be observed. Ragweed, sandbur, and Canada fleabane remain the most important species. The prairie plants, represented by *Euphorbia corollata* and the *Andropogons*, have increased somewhat and a fourth species, *Lespedeza capitata*, appears as a prominent invader. Prairie plants are but a minor part of the flora in the fields at this stage; the weeds are still very prominent. *Hedeoma pulegioides*, *Agrostis scabra*, and *Physalis virginiana* appear, *Poa compressa* increases, and *Myrica asplenifolia*, which is later of great importance, gains a foothold. In one field, in T18N R3E S2NW, abandoned one year in 1936, sandbur was very abundant. In 1937 it had disappeared entirely but in 1938 it had again become prominent. This is rather exceptional, for sandbur is one of the critical species in the succession. In most of the fields observed this species disappeared after two years and none was present in fields abandoned for three years or more except where the fields had been disturbed. In the older fields sandbur appears as a result of heavy grazing, as it did in a ten-year field, or as a result of some other disturbance such as driving a car or wagon across the field. Sandbur then appears in the ruts. An attempt was made to see if the seeds of this plant remained viable in the soil and then germinated after disturbance by taking some of the soil of a field which had been abandoned for twenty-two years and placing it in shallow trays in the greenhouse. Several months afterwards, *Mollugo verticillata*, *Rumex Acetosella*, *Poa compressa* from the rhizomes, and *Antennaria* sp. had appeared but sandbur had not. It would be interesting to know how long the seeds of this species can remain viable while buried in the soil. The rapidity with which it becomes established in freshly cultivated fields on the sandy soils in this county is remarkable. The lesser ragweed, *Ambrosia artemisiifolia*, presents a situation comparable to the sandbur. It is abundant during the first three years following abandonment, then practically disappears, persisting in the fields only as a result of grazing or some other disturbance. Since this is a valuable game bird food plant, it is important that some fields under cultivation, or abandoned for not more than three years, be available as a food reserve on game preserves in this area.

Three years after abandonment the amount of ragweed decreases slightly and Canada fleabane becomes more dominant. *Lespedeza capitata* becomes slightly more common. *Oenothera biennis* has also risen in frequency. *Aristida basiramea*, *Asclepias tuberosa*, *Helianthus occidentalis*, and *Carex pensylvanica* are the important new invaders. As already mentioned, *Cenchrus pauciflorus* has disappeared in most fields except in disturbed spots.

In the one field observed five years after abandonment *Lespedeza capitata* and *Euphorbia corollata* had increased greatly. Four other prairie species appeared in the field: *Coreopsis palmata*, *Asclepias tuberosa*, *Litho-*

spermum gmelini, and *Andropogon scoparius*. These were not abundant. The observer unfortunately made no note of the weed flora in the field.

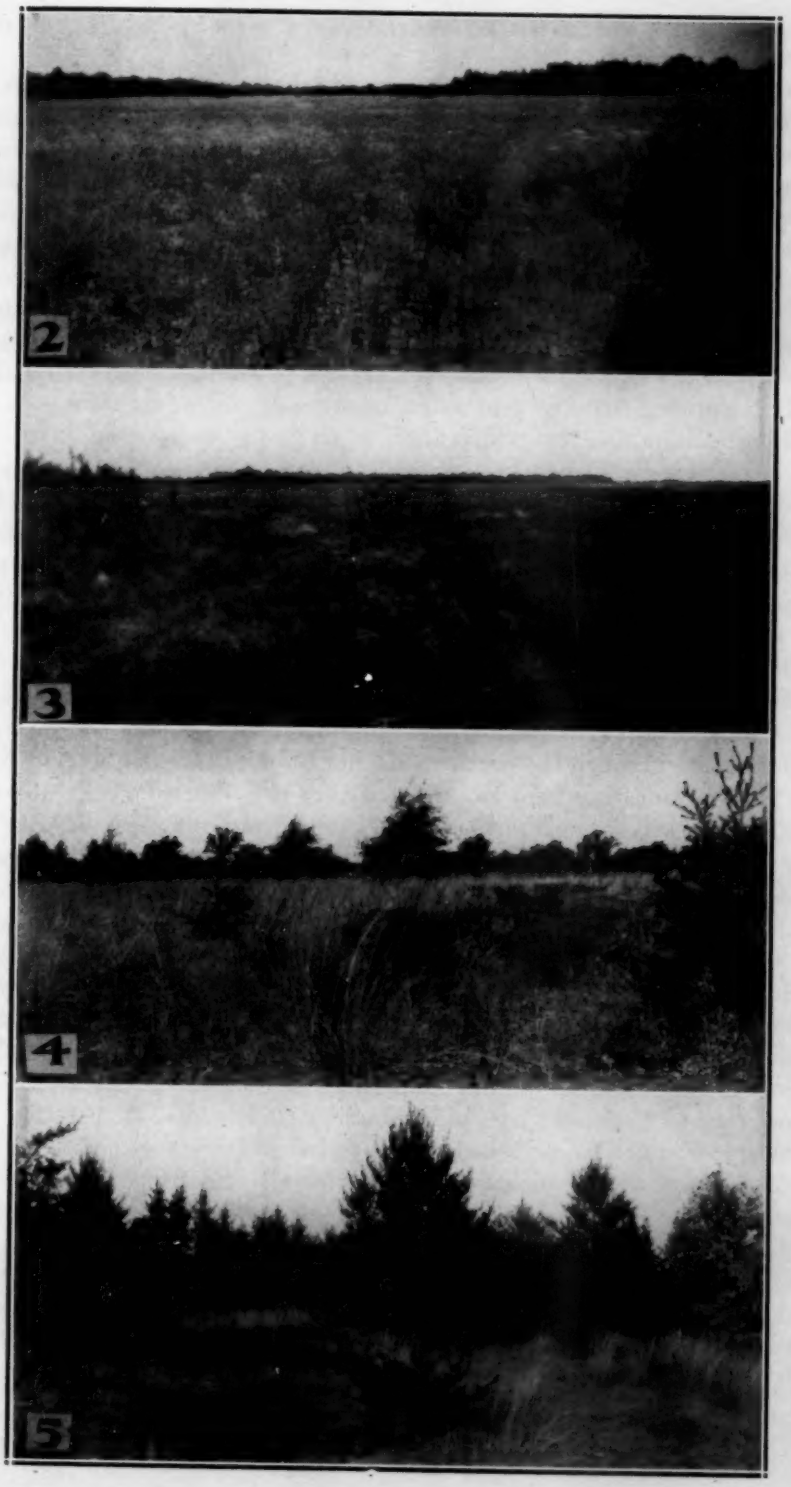
In fields which have been abandoned for nine or ten years the change in successions has slowed up somewhat. They are quite similar to four- or five-year abandoned fields, although the prairie species have increased in general in numbers of plants and of species. *Hieracium longipilum*, *Baptisia leucophaea*, and *Desmodium illinoense* have appeared. *Euphorbia corollata* and *Lespedeza capitata* have become important, but there is still much *Aristida basiramea* and *Erigeron canadensis*.

The single observed field of eleven years age of abandonment had been so heavily grazed that the succession upon it could hardly be termed typical. The hooves of cattle had so cut up the soil that great quantities of sandbur were present and the plants remaining in the field were mostly species unpalatable to cattle.

Twelve-year fields show an increase in the plants of the prairie species, especially of *Andropogon scoparius*, *Lespedeza capitata*, and *Euphorbia corollata*. *Erigeron canadensis* and *Aristida basiramea* begin to drop in importance. *Pinus banksiana* appears in fields of this age and increases from this time on. The patches of *Rubus* sp. and *Myrica asplenifolia* are becoming conspicuous. By the time the fields have been abandoned for fifteen years the prairie species have reached their maximum both in number of individuals and in number of species present in the fields. There is a fairly solid turf of *Andropogon scoparius*. *Lespedeza capitata* and *Euphorbia corollata* are very common. *Hieracium longipilum*, *Liatris scariosa*, *Helianthus occidentalis*, and *Lupinus perennis* var. *occidentalis* are present. Up to this time in the succession the distribution of each species has been fairly even throughout the field but now the various species begin to appear in patches rather than evenly distributed. This tendency becomes more accentuated in the older fields. Probably this tendency is caused in part by the severe competition in the field and the micro-conditions within the field limit the distribution of each species. The dominance of the prairie species persists in the fields from fifteen to twenty-two years abandoned but in the older fields, although the same species are present, the patches of distribution of the major species become more pronounced and the shrubby and woody plants, *Myrica asplenifolia*, *Rubus* sp., *Rhus glabra*, and *Pinus banksiana* become more prominent. *Carex pensylvanica* becomes more common.

Explanation of figures 2–5

FIG. 2. A field abandoned one year, T2ON R5E S6. Ragweed is the most conspicuous plant. FIG. 3. A field abandoned three years, T18N R3E S2. *Agrostis scabra* showing as white patches in the foreground, *Lespedeza capitata* in the background. FIG. 4. A field abandoned fifteen years, T19N R2E S17. Note abundance of *Andropogon scoparius*, scattered *Pinus banksiana*. Dark area is *Myrica asplenifolia*. FIG. 5. A field abandoned thirty-five years, T19N R3E S27. Photo shows scattered *Andropogon scoparius;* vigorous invasion by *Pinus banksiana* and a single *Populus grandidentata* at right.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By the time the field has been abandoned for thirty-seven years the forest has encroached considerably on the prairie flora. Jack pine, *Pinus banksiana*, is the dominating member of the flora and *Populus grandidentata* is also present. Shrubby plants including *Myrica asplenifolia*, *Corylus americana*, young *Quercus ellipsoidalis*, and *Rubus* sp. occupy considerable territory. *Carex pensylvanica* is common in the slight depressions in the field, forming an almost continuous turf. The prairie species have dwindled in importance and are present only in a few scattered clumps of *Euphorbia corollata*, *Andropogon scoparius*, *Koeleria cristata*, and *Lespedeza capitata*. *Baptisia leucophaea* and *Coreopsis palmata* are present as a few plants. *Liatris scariosa* was growing near the field in the open scrub oak woods but not in the field itself.

Later succession can be but conjectured, since the oldest field upon which observations were made had been abandoned thirty-seven years. In this field and on several of the other abandoned fields, young oaks were growing. In an abandoned field in Monroe County, just west of Mather, there is a thick growth of jack pine but a few young oaks are present among them. Since the oaks are more tolerant of shading than the pine, they would survive until some accident to the pines would open up a space for growth of the oaks, when they would begin growing rapidly and shade out the younger pines which might start. In this way an interspersion of oaks and jack pine would result. Through the northern part of Juneau County the land which was cut over and then kept as stump pasture has reverted to oak and pine woods. The early surveys made in 1851 record mixed forests of oaks and pines. While some of the finest stands of white pine in the country were present in Juneau County, they were on the moister soils, and the forest at the time of settlement was a mixed one. Over most of the area on which the white pine formerly grew cultivation and fires which followed the lumbering have destroyed most of the organic matter in the soil. To restore the soil to a condition suitable for a flourishing stand of white pine over much of the area would require centuries. Accordingly it would appear that the climax of succession on the dry sandy soils in Juneau County would be a mixed forest of oak and jack pine. *Quercus ellipsoidalis*, *Q. velutina*, and *Q. macrocarpa* are the principal oaks involved in the succession.

The causes of the succession are not at all understood, nor why the changes in the flora during the first years after the field is abandoned are rapid while later changes are more gradual. In Iowa Shimek[3] found that the prairie plants had become established in a field ten years after it was abandoned but that thirty years were required for complete establishment. Here in Juneau County the succession of prairie plants is a little slower,

[3] **Shimek, B.** Papers on the prairie. Univ. Iowa Studies in Nat. Hist. 5: 1–36. 1925.

requiring fifteen years, and is never complete, since the forest closes in by the time a field has been abandoned for thirty-five years. The perennials of the prairie flora type may replace the annuals of the weed type in the early years because they are better able to start growth in the spring and because they have more efficient root systems. But the disappearance of such species as the lesser ragweed may be dependent upon the rapid oxidation of organic matter such as manure in the dry sandy soils. Obviously the nutrient requirements of the plants and their water and light relations ought to be investigated. Some inquiry should be made into the soil conditions as affecting the growth of the plants; for changes within the soil may be responsible at least in part for the floral succession. One such type of experimentation would be to test the growth of the various important plants in the succession on soil samples taken from fields of varying ages of abandonment in order to determine whether there is an effect of the soil on germination, on growth of the seedling or on growth of the mature plant. Both topsoil and subsoil would have to be tested.

SUMMARY

The plant succession on abandoned fields in Juneau County, Wisconsin, is from a weed flora the first few years, with rapid changes in the succession, to prairie plants which appear in numbers at from nine to ten years after the fields are abandoned, and reach a maximum at about fifteen years after the fields have been abandoned. Finally the prairie plants decline as the forest represented by jack pine and oak becomes the climax.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 42–49 JANUARY, 1943

THE TAXONOMY OF THE MONOGENERIC TRIBE ELVASIEAE (OCHNACEAE)

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In 1811 De Candolle described the genus *Elvasia*[1] with a single species, *E. calophyllea*, and placed it in the Ochnaceae. Planchon in describing in 1848 the genus *Hostmannia* related it to *Elvasia*. In a later work Engler made *Hostmannia* a subsection of *Elvasia*, combining it with Planchon's subsection *Euelvasia*. Van Tieghem, the first worker to introduce radical changes into the genus, divided *Elvasia* into 4 genera, grouping the quartet under the tribe Elvasieae (Elvasiées) and Hostmannieae (Hostmanniées) of the subfamily Elvasiodeae. Gilg in the most recent treatment of the genus (1825) elected to retain Engler's 2 subsections.

This study of the genus *Elvasia* is a sequel to the author's work on the American species of the Luxemburgieae.[2] Although fourteen collections of *Elvasia* form the basis of this study of seven species, apparently no more than nineteen collections of this genus are deposited in herbaria or are cited in the literature. Six of my specific descriptions are based on type material.

Elvasia is limited to British Guiana, Surinam, Venezuela, and Brazil. Several collections made in the western part of the State of Amazonas, Brazil, indicate that this may be the center of distribution of the genus. *Elvasia* includes moderately sized trees and shrubs; members of the genus are not reported as being of economic importance. According to Pittier, in his discussion following the original description of *E. carunensis*, this species is known among the natives as *Manteco de Agua*. The brief history of *Elvasia* suggests that its position in the Ochnaceae is a sound one. The general structure of the pistils points especially to its relationship with the large ochnaceous genus *Ouratea*. This is evidenced by its usually lobed and short-stipitate ovary with axillary placentation. Each cell of the ovary bears an ovule which in fruit develops into an exalbuminous seed. On the other hand its affinity with the tribe Luxemburgieae is manifested in the constantly slender, crowded, and immersed secondary veins of the leaf-blades, a character found in *Blastemanthus* and *Wallacea* of the Luxemburgieae. The scarious sepals and the oblong, basifixed, and early deciduous anthers borne on slender persistent filaments resemble those of several genera of this tribe. Perhaps the most important character linking the Elvasieae

[1] Named by De Candolle in honor of Francois Manuel D'Elvas, who was, in the words of the author (Ann. Mus. Paris **17**: 408. 1811) "jésuite portugais qui le premier a écrit sur l'histoire naturelle du Brésil."

[2] This study is at present in manuscript form.

and the Luxemburgieae is the distinct radial stigmas of the section *Euelvasia*, which are strikingly reminiscent of the sessile radiating stigmas of the *Cespedezia*, *Godoya*, and *Rhytidanthera* complex of the Luxemburgieae. The tribe Elvasiae stands apart from both the Ourateae and the Luxemburgieae because of the unique structure of its fruit. In this the homologues of the lobes of the ovary dilate laterally from a median disc as ray-like structures; a solitary basifixed seed develops in the hollow of the disc left by the abortion of the walls of the carpels.[3] The inconstant number of carpels found in several species of *Elvasia* is not found in the genera of the Luxemburgieae and Ourateae.

While intragenerically the author maintains the two subdivisions *Euelvasia* and *Hostmannia*, which are based on differences in the number of carpels, further study indicates that a break in *Euelvasia* is necessary on the basis of stigmatic differentiation coupled with variations in the number of stamens. A third division, *Euessequibensa*, is proposed in this paper. General studies on the family Ochnaceae make it clear that carpellary variations in the species of the American genera are rare. In my opinion the variation in stigmatic structure in *Elvasia* is an exception to this stability, and is of equal importance as the equally exceptional variation in the number of carpels within the same genus. It is an interesting fact that fruiting material has been described only from the section *Euelvasia*. Whether the asteroid type of fruit, which characterizes the two species of this section of the genus, is found in the 5 species of the two other sections only additional collections of fruiting materials will disclose. One may anticipate a non-asteroid type of fruit for the section *Hostmannia* in which the carpels are reduced in number to two.

KEY TO THE SECTIONS

Ovary 4–5 celled; filaments of stamens (at late anthesis) not exceeding the anthers in length.
  Stamens 7–10; stigmas 4–5, fimbriate, radial (0.1–0.25 mm. long) ..... 1. *Euelvasia.*
  Stamens 10–20 (rarely up to 25); stigmas undifferentiated ..... 2. *Euessequibensa.*
Ovary 2-celled; filaments of stamens (at late anthesis) exceeding the anthers in length ..... 3. *Hostmannia.*

KEY TO THE SPECIES

1. *Euelvasia*

Leaf-blades dull-brown above.
  Sepals 3, 2.3–3 mm. long; petals 3–3.3 mm. long; stamens 7–8, the filaments 1.3–2.2 mm. long; disc of fruit not obvious, the rays distinctly marcescent-rugose, 2–3 mm. wide at base ..... 1. *E. calophyllea.*
  Sepals 4, 3.8–5 mm. long; petals 4–4.8 mm. long; stamens 10, the fila-

[3] Van Tieghem (Ann. Sci. Nat. VIII 16: 408. 1902) gives an excellent description of the development of the fruit.

ments 0.4–0.8 mm. long; disc of fruit obvious, the rays almost smooth, 4–5 mm. wide at base ..... 2. *E. quinqueloba.*
Leaf-blades cinero-canescent above ..... 3. *E. canescens.*

2. *Euessequibensa*

Leaf-blades 6–8 cm. long; branches of inflorescence subhorizontal, obviously unequal ..... 4. *E. brevipedicellata.*
Leaf-blades 9–20 cm. long; branches of inflorescence arcuate-ascending, subequal in length ..... 5. *E. essequibensis.*

3. *Hostmannia*

Sepals subrotund or ovoid-rotund, 2.8–3.8 mm. long; petals 4.6–5.6 mm. long ..... 6. *E. carunensis.*
Sepals elliptic to obovate-oblong, 5.5–6.5 mm. long; petals 6–9 mm. long. 7. *E. elvasoides.*

The materials cited in this paper have been secured from various American institutions which are designated by the following symbols:

F—Field Museum, Chicago, Ill.
G—Gray Herbarium, Cambridge, Mass.
NY—New York Botanical Garden, New York City, N. Y.
US—United States National Herbarium, Washington, D. C.

The author wishes to express his appreciation to the directors of the institutions listed above for their kindness in loaning him specimens. Special thanks are due to Dr. A. C. Smith of the Arnold Arboretum for his criticism of the manuscript.

ELVASIA DC. Ann. Mus. Paris **17**: 422. 1811.

Hostmannia Planch. in Hook Ic. Pl. **8**: pl. 709. 1848. *Vaselia* van Tieghem, Ann. Sci. Nat. VIII **16**: 409. 1902. *Trichovaselia* van Tieghem, Ann. Sci. Nat. VIII **16**: 411. 1902.

Trees or shrubs; leaf-blades subsessile or short-petiolate, coriaceous, acuminate, rarely retuse at apex, obtuse to cuneate at base, the costa slender and ridge-like, prominent, strigose, and hemispherical in cross-section below, becoming evanescent and plane toward apex, the secondary veins immersed, slender, crowded, leaving costa sub-horizontally, the margin entire, subcallose, often with minute, appressed, glandular teeth; stipules persistent or deciduous, deltoid to acute, axillary; buds subrotund to ovoid; inflorescence paniculate, terminal, the flowers solitary or in fascicles on slender, very short-articulate pedicels disposed on a smooth angular rachis terminating the twigs or rarely disposed on axillary branches, the bracts persistent or deciduous, carnose, oblong, very obtuse, the margin entire; sepals 3–5, quincuncial, carnose, reflexed or patent, soon deciduous at anthesis; petals 3–5, imbricate, carnose, reflexed or patent, deciduous at anthesis, yellow, the veins evanescent and flabellate toward margin, the latter entire; stamens 7–25, arranged in a circle about pistil, yellow, the anthers deciduous, 2-celled, dehiscing by 2 subterminal sub-auriculate pores usually slit-like at base, basifixed, the filaments free, slender, clavate at apex, persistent (even in young fruit); pistil solitary, the ovary short-stipitate, smooth or lobed, the carpels 2–5, fused, forming 2–5 cells, the ovules solitary per cell, oblong,

subplane, attached medianally or basally, the placentation axillary, the style persistent (up to immature fruit), subulate, the stigmas indeterminate or obviously 2 or disposed as 5 terminal radiate fimbriate projections of the style; fruit (known from two species) star-shaped, lignose, a single dorsoventrally subplane exalbuminous seed developing in a single locule, the remaining ovules and carpellary walls aborting.

TYPE SPECIES: *Elvasia calophyllea* DC.

1. ELVASIA CALOPHYLLEA DC. Ann. Mus. Paris **17**: 422. 1811. *Elvasia sprucei* van Tieghem, Ann. Sci. Nat. VIII **16**: 409. 1902. *Elvasia schomburgki* van Tieghem, Ann. Sci. Nat. VIII **16**: 409. 1902.

Small trees; leaf-blades usually deflexed, often revolute, oblong-lanceolate, 4–6.5 cm. long, 2.5–4 cm. wide, tapering into an acuminate point or flat-obtuse at apex, obtuse-cuneate at base; stipules apparently persistent; inflorescence terminal, the rachis exceeding the uppermost leaves, up to 15 cm. long, the branches sub-horizontal, becoming shorter toward apex, the flowers dense, solitary or fasciculate on slender pedicels 3–8 mm. long, the bracts slender-subulate, 1–3 mm. long, deciduous; sepals 3–4, concave, obovate-rotund or obovate-oblong, 2.3–3 mm. long, 1.2–2.6 mm. wide, the veins subparallel, irregular-ascending, well-spaced and forming toward margin a loose flabellate reticulum; petals 4, subequal, oblong-rectangular or suboblong, 3–3.3 mm. long, 1.3–1.6 mm. wide, round-obtuse toward apex, tapering slightly toward base, the veins evanescent; stamens 7–8, the anthers plump, ovate-oblong to narrow-ovoid, 1–1.3 mm. long, about 0.5 mm. wide at base, the filaments 1.3–2.2 mm. long; pistil stipitate (for about 0.2 mm.), 4–5-lobed and -celled, rhomboid in outline, about 1 mm. wide, the style 1.3–2.8 mm. long, somewhat swollen at base, bearing 5 radial and fimbriate stigmas at apex, each stigma about 0.2 mm. long; fruit dull gray-black, 4–5-rayed, up to 2 cm. in diameter, the rays distinctly rugose and contorted, unequal, the disc scarcely evident, the seeds orbicular, about 2.5 mm. wide, depressed above.

Type Locality: Brazil.

Illustration: DC. Ann. Mus. Paris 17: *pl. 31.* 1811.

Distribution: Known from British Guiana and the State of Amazonas, Brazil. BRITISH GUIANA: *Schomburgk 940* (F, photo and frag., G, type collection of *E. Schomburgki*), *Schomburgk 941* (?) (F). BRAZIL: Without definite locality or collector, labelled De Candolle (F, photo and frag. of type of *E. calophyllea*); AMAZONAS: Barra, Rio Negro, *Spruce 1792* (F, photo, G, photo, NY, type collection of *E. Sprucei*); Santa Izabel, *Ducke 56* (F, NY).

A thorough search of the literature, including the monograph in which the original description is found, failed to reveal the collector of the type material or the exact locality in which the type was collected. *E. calophyllea,* the type species is the most collected member of the genus. The reduction in the number of stamens (7–8) is its most outstanding specific floral character.

2. ELVASIA QUINQUELOBA Spruce ex Engler in Mart. Fl. Bras. **12** (2): 353. 1876. *Vaselia quinqueloba* van Tieghem, Ann. Sci. Nat. VIII **16**: 409. 1902.

Trees (?); leaf-blades often revolute, oblong, 10–15 cm. long, 3–5 cm. wide, acute at apex, cuneate at base; stipules persistent or deciduous, 2–3

mm. long; buds obovate-oblong, about 4 mm. long; panicle exceeding uppermost leaves, pyramidal, the branches subhorizontal, the pedicels about 3 mm. long, the lowermost bracts often persistent, narrow-subulate, 2.5–3 mm. long, very acute; sepals 4, concave, oblong, ovate-oblong or rectangular, 3.5–5 mm. long, 1.5–3 mm. wide, obtuse at apex and base, the veins few, well-spaced, parallel-ascending, flabellate toward margin; petals 5, obovate-oblong, 4–5 mm. long, 2–2.5 mm. wide, obtuse at apex, cuneate at base; stamens 10, the anthers linear-rectangular, about 3.5 mm. long, about 0.8 mm. wide, the filaments 0.4–0.8 mm. long; ovary smooth or distinctly lobed, 3–5-celled, rhomboid or subrotund in outline, about 0.9 mm. long, often wider than long, the style slender-subulate or thick-subulate (up to 0.5 mm. wide at base), 3–3.5 mm. long, the stigmas 5, fimbriate, radial, each stigma about 0.15 mm. long; fruit 4–5-lobed, 1–1.5 cm. in diameter, the rays red-brown, subsmooth, 3–5 mm. wide at base, the partitions persistent above, slender prominent, the seed about 6 mm. wide.

Type Locality: Rio Guainia and Rio Negro, above mouth of Rio Casiquiare, Amazonas, Brazil.

Illustration: Engler in Mart. Fl. Bras. **12** (2): *pl. 71. f. 1.* 1876.

Distribution: Known only from the type locality. BRAZIL—AMAZONAS: Rio Guainia and Rio Negro, above mouth of Rio Casiquiare, *Spruce 3513* (*3398*) (F, G, photo and type collection).

This species is obviously related to *E. calophyllea;* it is distinguished from the latter by being stouter in all its parts and by its distinctly oblong leaves.

3. ELVASIA CANESCENS (van Tieghem) Gilg in Engler & Prantl, Nat. Pflanzenfam. ed. 2. **21**: 77. 1925. *Trichovalesia canescens* van Tieghem, Jour. de Bot. **16**: 205. 1902.

Small trees, 4–5 m. high; leaf-blades ashen-brown or waxy-farinose above, canescent, brown beneath, obovate-oblong, about 5 cm. long, 2 cm. wide, flat-obtuse to deltoid (often retuse and truncate) at apex, subcuneate at base, the margin with minute purple hairs about 1 mm. apart, curved downward; stipules persistent, subdeltoid, about 1 mm. long, about 1 mm. wide at base, acuminate; panicle terminal, pyramidal, about 8 cm. long, the branches slender, subhorizontal, densely flowered, the flowers solitary, the pedicels about 5 mm. long, the bracts concave, narrow-deltoid or subulate, about 3 mm. long; sepals 3–4, unequal, reflexed at anthesis, obovate-oblong or oblong, 2.3–4.3 mm. long, 1.2–2.7 mm. wide, obtuse to flat-obtuse at apex, obtuse at base, the veins 3–6, conspicuous or evanescent, branching flabellately above middle; petals 3–5, unequal, obovate-oblong or oblong, 2.6–5 mm. long, 1.3–2.5 mm. wide, round-obtuse or deltoid at apex, obtuse-cuneate at base, stamens 7–12, the anthers plump, linear-ovoid to elliptic, 1.35–1.5 mm. long, 0.5–0.8 mm. wide, the filaments 0.7–1.6 mm. long; pistil stipitate, the stipe 0.1–1 mm. long, the ovary 4–6-lobed, the lobes drooping, compressed-rhomboid in shape, 0.5–1 mm. long, 0.8–1.1 mm. wide, the style thickly subulate, 1.4–4.5 mm. long, the stigmas 4–6, terminal, radial, and fimbriate; fruit not seen.

Type Locality: San Fernando, Atabapo, Amazonas, Venezuela.

Distribution: Known from the type locality and from the state of Amazonas, Brazil. VENEZUELA—AMAZONAS: San Fernando, Atabapo, *Gaillard*

168 (F, photo and frag. of TYPE). BRAZIL—AMAZONAS: Rio Curicuriary and Rio Negro, *Ducke 356* (F).

Of the seven species of *Elvasia* listed in this paper, *E. canescens* is the most easily recognized, because of the distinctly canescent upper surface of the leaf-blade.

4. ELVASIA BREVIPEDICELLATA Ule, Notizbl. Bot. Gart. Berlin **6**: 339. 1915.

Trees 5–10 m. high; leaf-blades oblong, 6–8 cm. long, 2.5–3.5 cm. wide, acuminate at apex, wide-cuneate at base; panicle 3–5 cm. long, shorter than leaf-blades, the branches unequal, very short, the pedicels 3–4 mm. long; sepals 4 or more, about 6 mm. long, 4 mm. wide; petals subequal in length, spatulate-elliptic, about 6 mm. long, 4 mm. wide; stamens 20–25, the anthers exceeding the filaments in length, the latter about 1 mm. long, the anthers about 2.5 mm. long; ovary 5-celled, ovoid, about 1 mm. long, the style filiform, about 2 mm. long; fruit not seen.

Type Locality: Mt. Roraima, 1900 m. alt., British Guiana-Venezuela boundary.

Distribution: Known only from the type locality. BRITISH GUIANA—VENEZUELA BOUNDARY: Mt. Roraima, 1900 m. alt., *Ule 8664* (G, photo of type).

While the above description is based on a photograph of the type and on Ule's original description, there seems to be no doubt that this species is related to *E. essequibensis*. Unfortunately Ule does not discuss its stigmatic structure, but the number of stamens surrounding 5 carpels is a strong indication of its relationship with *E. essequibensis*.

5. ELVASIA ESSEQUIBENSIS Engler in Mart. Fl. Bras. **12** (2): 354. 1876. *Hostmannia essequibensis* van Tieghem, Ann. Sci. Nat. VIII **16**: 414. 1902.

Small trees or shrubs; leaf-blades dull gray-brown above, oblong, 9–20 cm. long, 3.5–8 cm. wide, conspicuously attenuate-apiculate at apex, the blade frequently splitting along the secondary veins, the margin subrevolute, entire, with minute black-glandular teeth, up to 0.5 mm. long; stipules persistent, elongate-deltoid, 3–5 mm. long, acute; buds rotund or oblong, about 3 mm. long at maturity; inflorescence terminal, patent-paniculate, the flowers in dense fascicles on the arcuate-ascending subequal branches, the latter equal to or exceeding the uppermost leaf-blades, the pedicels 2–4 mm. long, the bracts widely subulate, up to 3 mm. long, attenuate at apex; sepals 5, unequal, oblong, oblong-rectangular or obovate-oblong, 2.8–4.2 mm. long, 2–2.3 mm. wide, obtuse at apex, obtuse to subcuneate at base, the veins 6–8, conspicuous, well-spaced; petals 5, oblong-obovate, obovate-rotund or oblong, 4.7–5 mm. long, 2.3–4.3 mm. wide, obtuse (frequently retuse) at apex, subobtuse to cuneate at base, the median veins distinct, the lateral veins usually evanescent and flabellate; stamens 11–18, the anthers linear-rectangular, 2.2–3.2 mm. long, 0.5–0.8 mm. wide, the filaments 1–1.3 mm. long; ovary very short-stipitate, the stipe up to 1 mm. long, 4–5-celled, 0.7–1.3 mm. long, the style 2–4.5 mm. long, often contorted or transverse-rugose, constricted and markedly truncate at apex, the stigmas a plane surface; fruit not seen.

Type Locality: Essequibo River, British Guiana.

Illustration: Engler in Mart. Fl. Bras. **12** (2): *pl. 71, f. 2.* 1876.

Distribution: British Guiana. BRITISH GUIANA: Mazaruni & Cuyuni Rivers, *Graham 153* (NY); Essequibo River, *Jenman 1325* (NY).

This species is readily recognized by its constantly large and markedly oblong leaf-blades and arcuate-ascending branches of the inflorescence.

6. ELVASIA CARUNENSIS Pittier, Bol. Soc. Venez. Cien. Nat. **6** (41): 75. 1939.

Trees up to 15 m. high, the branches above middle of trunk; leaf-blades narrow-lanceolate, 7–15 cm. long, 2.5–4.6 cm. wide, acute and narrowly acuminate at apex, cuneate at base; stipules deciduous, striate, deltoid, up to 5 mm. long, the free lobes deltoid and long-acuminate; buds rotund, about 2.5 mm. wide; inflorescence terminal, not exceeding uppermost leaves in length, pyramidal, the flowers fasciculate on the horizontal whorled branches, the pedicels long, the bracts subconcave, widely subulate-deltoid, up to 3 mm. long; sepals 3–4 smooth, unequal, subrotund or ovoid-rotund, 2.8–3.8 mm. long, 2.6–3 mm. wide, obtuse at apex and base, the veins parallel-ascending, well-spaced, branching loosely above middle; petals 3–4, reflexed at anthesis, obovate or obovate-oblong, 4.7–5.6 mm. long, 2.2–3.3 mm. wide, obtuse at apex and base, the veins flabellate and immersed; stamens 15–21, the anthers plump, ovate-oblong, 2–2.3 mm. long, about 1 mm. wide, the filaments 1.2–2.5 mm. long; ovary smooth, rotund or rhomboid, 1.2–2.4 mm. long, 1.2–1.5 mm. wide, 2-celled, 2-ovuled, the style thick-subulate or slender and contorted, 1.7–7.5 mm. long, the stigmas undifferentiated or the style grooved above the middle and bearing two lateral stigmatic surfaces at apex; fruit not seen.

Type Locality: El Pescado, Bolivar, Venezuela.

Distribution: Known only from the type locality. VENEZUELA—BOLIVAR: El Pescado, 140 m. alt., *Llewelyn Williams 11525* (F, NY, type collection).

Pittier, in his discussion following the original description of *E. carunensis*, states that the number of stamens is constantly 17. My counts of the stamens in type material show them to vary from 15–21. This species shows its close relationship with *E. elvasoides* in its vegetative habit as well as in the number of the stamens, length of the filaments, number of the cells of the ovary, and its stigmatic differentiation. Notable differences are apparent: *E. carunensis* has smaller flowers, subrotund or ovoid-rotund sepals, and the usually rhomboid-shaped ovary.

7. ELVASIA ELVASIODES (Planch.) Gilg in Engler & Prantl. Nat. Pflanzenfam. III **6**: 145. 1893. *Hostmannia elvasiodes* Planch, in Hook Ic. Pl. **8**: pl. 709. 1848. *Elvasia Hostmannia* Planch. Lond. Jour. Bot. **5**: 648. 1846. *Hostmannia Sagoti* van Tieghem, Ann. Sci. Nat. VIII **16**: 414. 1902.

Trees; leaf-blades oblong to oblong lanceolate, 5–8 cm. long, 2–3.5 cm. wide, abruptly acuminate at apex, cuneate at base; stipules persistent, blackish, widely subulate, 3–4 mm. long, the margin erose; buds subrotund, about 4 mm. long at maturity; inflorescence terminal or on axillary branches, equal to or exceeding the uppermost leaf-blades in length, compressed pyramidal-paniculate, the branches subhorizontal or obviously ascending, the flowers dense, solitary or fasciculate, the pedicels slender, 4–9 mm. long, the bracts concave, oblong or rectangular, about 3 mm. long, the margin hyaline or somewhat irregular; sepals 4, reflexed at anthesis, thin-carnose, subequal in length and width, elliptic to obovate-oblong, 5.5–6.5 mm. long, 3–3.5 mm. wide, obtuse to subdeltoid at apex, obtuse to subcuneate at base, the veins about 6, well-spaced and parallel-ascending; petals 4, thin-carnose,

unequal, reflexed at anthesis, obovate-spatulate, obovate-oblong, or obovate, 6–9 mm. long, 3–4 mm. wide, obtuse at apex, wide-cuneate to obtuse at base, the veins few subflabellate from a somewhat swollen midvein; stamens 17–21, the anthers oblong, about 3 mm. long, 1 mm. wide, the filaments slender, 2–3.6 mm. long, exceeding anthers in length; ovary smooth, vaguely lobed, ovoid-rotund in outline, 1.1–1.6 mm. wide, the style subplane, subulate, thickened toward base, 2-grooved above middle, 5–6 mm. long, the stigmas 2 or simply indeterminate, the ovary 2-celled, the 2 ovules about 0.8 mm. long, attached sub-basally; fruit not seen.

Type Locality: Dutch Guiana.

Illustration: Planch. in Hook, Ic. Pl. **8**: *pl. 709.* 1845.

Distribution: French and Dutch Guianas. DUTCH GUIANA: *Hostmann 271* (F, type collection); Marowyne River, *Kappler 1725* (F). FRENCH GUIANA: Karouany, *Sagot 786* (F, photo and frag. of TYPE of *Hostmannia Sagoti*).

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 50–52 JANUARY, 1943

KAIETEUREA, A NEW GENUS OF THE OCHNACEAE

JOHN D. DWYER

Kaieteurea Dwyer, gen. nov. Arbores vel suffrutices; laminae simplices, subsessiles ad apicem ramulorum persistentes coriaceae, costa supra infraque prominente, venis secundariis evanescentibus prominulis vel submersis, margine integro; gemmae ovoideae; stipulae ovoideae caducae; inflorescentia terminalis floribus solitariis, alibus in ramis racemosis axillaribus et alibus in paniculatis rhachidibus virgas terminantibus dispositis, pedicellibus recurvatis gracilibus, bracteis persistentibus aut caducis parvis obtusis margine integro; sepala 2 (rare 3), opposita aut alterna in gemma concrescentia marginibus non-imbricatis carnosa persistentia (in etiam fructu); petala 3–4 mox decidua carnosa oblonga margine integro; stamina 10, antheris mox deciduis transverse-rugosis lineari-rectangularibus 2-poris terminalibus dehiscentibus, fllamentis liberis subnullis; pistillum solitarium, ovario stipitato in annulum 5 carpellis dispositis 5-locularibus ovulo solitario in utroque loculo, stylo uno terminale subulato, stigmatibus nullis; fructus stipitatus solitaria drupa dispositus rotundatis sepalis involutus, semini solitario exalbuminoso.

Trees or shrubs; leaf-blades simple, subsessile, persistent at the apices of the branches, coriaceous, the midrib prominent above and below, the lateral veins evanescent or immersed, the margin entire; buds ovoid; stipules deciduous; inflorescence terminal, the flowers solitary, some arranged on racemose axillary branches, others on a paniculate rachis terminating the twiglets, the pedicels slender, recurved, the bracts persistent or deciduous, small, obtuse, the margin entire; sepals 2, (rarely 3), fused in bud, opposite, carnose, persistent (even in fruit); petals 3–4, soon deciduous, carnose, oblong, the margin entire; stamens 10, the anthers soon deciduous, transversely rugose, linear-rectangular, dehiscing by two terminal pores, the filaments free, scarcely measurable; pistil solitary, the ovary stipitate, 5-carpellate, the carpels arranged in a ring, 5-celled, a single ovule in each cell, the style solitary, terminal, subulate, the stigmas non-differentiated; fruit stipitate, solitary, drupaceous, rotund, enclosed by the persistent sepals, the seed solitary, exalbuminous.

Carpellary studies leave no doubt that *Kaieteurea* is related to the ochnaceous genus *Ouratea*, well-known to workers in the floras of the new and old worlds. The five fused and uniovulate (one ovule per locule) carpels arranged in a circle atop a conspicuous stipe and terminated above by a subulate style with undifferentiated stigmas are unmistakably similar in both genera. *Kaieteurea*, while similar to *Ouratea* in vegetative habits and structure, shows marked differences in its fruit and flowers. In fruit, the torus becomes lignose, scarcely expands, and bears a single drupe encased in the two erect persistent sepals. The absence of endosperm in the seed places *Kaieteurea* together with *Ouratea*, *Ochna*, *Brackenridgea* (Ourateae), and *Elvasia* (Elvasieae) in the primary subdivision of the Ochnaceae, Exalbuminosae. On the basis of fruit structure further study may prove that *Kaieteurea* is deserving of tribal rank. The floral differences are equally

striking. The new genus, unlike any other American genus of the Ochnaceae, frequently has one pair of opposite sepals; this is a marked deviation from the quincuncial arrangement of the sepals which typifies *Ouratea*, *Elvasia*, and the majority of the genera of the Luxemburgieae. The marked reduction in the number of sepals to 2 is a condition not met with in the above genera and tribe. Critical examination of the margins of the sepals of *Kaieteurea* shows that these are fused in the bud and at anthesis are torn apart. The persistence of the sepals as well as their erect habit in the fruit point to the relationship of the new genus to the Luxemburgieae, many of whose genera have the sepals persistent and erect in the fruit. Accompanying the marked reduction in the number of sepals is a frequent reduction in the number of petals to 3. *Ouratea*, with the exception of odd and obviously abnormal flowers, is distinctly pentamerous. The biporous, linear-rectangular, and transversely rugose anthers of *Kaieteurea*, which are borne on scarcely measurable filaments and disposed in a single circle at the base of the stipe, are the prototypes of those of *Ouratea*. This relationship is further manifested in the constancy in the number of the stamens.

Kaieteurea derives its name from the Kaieteur Savanna, British Guiana, where the type-species was collected. Potaro Landing, Kaieteur Savanna, is the home of a considerable number of endemics.

Kaieteurea gillyana Dwyer, sp. nov. Arbores vel suffrutices; folia ad apicem ramulorum conferta; petiolo brevi, circular 3–8 mm. longo suffulta, lamina ascendente coriacea brunnea rigida glaberrima oblonga, 3–5 cm. longa, 1.2–2.5 lata, ad apicem et ad basim distincte cuneata, costa supra in culminem elevata, circ. 0.5 mm. lata, supra prominente infra longitudinostriata ad basim circ. 2 mm. lata apice evanescente, nervis secundariis subobscuris, alibus paucis distantibus arcuato-ascendentibus prominulis juxta costam margine subprominentibus, alibus multis crebris irregularibus a costa ad angulum 80° abeuntibus, margine integro; gemmae ovoideae, circ. 5 mm. longae, acutissimae; inflorescentia ad apicem virgarum multis ramis racemosis ab superiorum laminarum axillis singulatim orientibus et in modum paniculae caulem extrahentis disposita latidudine subaequalibus et vix longioribus superioribus rhachidibus ramisque lignosis angularibus striatis subtortisque, floribus crebris, pedicellis recurvatis, 0.5–1 cm. longis, gracili-marcescenti-striatis singulatim dispositis, bracteis persistentibus aut deciduis concavis oblongis, circ. 1.5 mm. longis; sepala 2 (rare 3), opposita persistentia (in etiam fructu) rubro-brunnea carnosa longitudine vix marcescenti-striata ovata vel ovato-rotunda, 5.5–6 mm. longa, 4.5 mm. lata, ad apicem late deltoidea ad basim obtusa; petala 3–4 subaequalia caduca carnosa rubro-brunnea (?) oblonga, circ. 7.5–8 mm. longa, 3–3.9 lata, ad apicem obtusa retusaque (sinu circ. 0.5 lata) ad basim obtusa; stamina 10, uniseriata, anthera transverse-rugosa rubra linearirectangularibus saepe in medio geniculatis, circ. 5.5 mm. longis, ad basim 1–1.5 mm. latis, 4-locularibus interioribus (eorum) vix brevioribus augustioribus ad apicem biporosis; pistillum solitarium stipitatum (stipite 0.5–1 mm. longo), ovario carnoso 5-loculare 5-ovulato aequale distincteque lobato, depresso-rotundo, circ. 1.5 mm. lato, circ. 0.6 mm. longo, ovulis loculos complentibus sublongis, circ. 0.5 mm. longis, basifixis, stylo-filiformi, circ. 4 mm. longo, stigmatibus nullis; fructus stipitatus (stipite recto nigro lignoso mar-

cescente clavato, circ. 2.5 mm. longo, apice 2.5 mm. lato) vix marcescens rotundatus sepalis involutis, semini solitario exalbuminoso.

Distribution: Known only from the type locality. BRITISH GUIANA: Potaro Landing, Kaieteur Savanna, *Jenman 863* (NY TYPE).

This species is named for Mr. Charles Gilly of the New York Botanical Garden who by his criticism assisted the author in his preliminary constructive work on the Ochnaceae.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 53–57 JANUARY, 1943

THE STATUS OF DISTICHLIS DENTATA

JOHN R. REEDER

While studying grasses collected in Eastern Oregon in the summer of 1941, the writer was impressed with the difficulty of separating *Distichlis dentata* Rydb. and *D. stricta* (Torr.) Rydb. None of the available keys was satisfactory and even the original description of *D. dentata* seemed vague. In view of this apparent confusion, a critical study was made of these two species and the conclusions reached are here presented.

For material kindly loaned for study, in addition to his own specimens and the collection at Oregon State College, the writer herewith expresses his appreciation to the United States National Herbarium, the Rocky Mountain Herbarium, and the University of Oregon. He is especially indebted to the New York Botanical Garden for the loan of types. Thanks are due also to Mrs. Agnes Chase for personal selection of specimens and for criticism of the manuscript and to Dr. Helen Gilkey for suggestions given throughout the progress of the study.

Rydberg (1909) described *Distichlis dentata* as differing from *D. stricta* and *D. spicata* "in the broader leaves, larger and broader spikelets, larger and broader floral glumes and palets in the pistillate plants, and in the distinct dentations on the keels of the latter." He cited collections from Washington, Oregon, Saskatchewan, and Nevada.

Fassett (1925), commenting on Rydberg's description, states: "In all these characters *D. stricta* is extremely variable, and while the conspicuously dentate paleas appear at first to be distinctive, this character breaks down when it is seen that almost all of the plants have the lemmas[1] somewhat dentate, and there is a difference only of degree." He places *D. dentata* in synonymy with *D. stricta*.

Hitchcock did not recognize either *D. stricta* or *D. dentata* until some time after 1923. In his *Genera of Grasses* (1920) and in Abrams' *Illustrated Flora of the Pacific States*[2] (1923) both *D. stricta* and *D. dentata* are listed as synonyms of *D. spicata*. However, in his *Manual of Grasses* (1935), Hitchcock recognized both of these species. His maps show *D. stricta* occurring in every state west of the Mississippi except Arkansas and Louisiana; *D. dentata* is listed as occurring only in Washington, Oregon, Idaho, Colorado, Nevada, Arizona, Utah, and Northern California.

Detailed study of the types of *D. dentata* and *D. stricta*, as well as of specimens from 17 western states, convinces the writer that *D. dentata* is not

[1] This is obviously an error. The word "lemma" should be palea.
[2] Key to the Grasses by A. S. Hitchcock.

a good species. The problem is complicated by the fact that the genus *Distichlis* is dioecious. Comparison of specimens labeled *D. dentata* with those labeled *D. stricta* indicates that the former has been separated entirely on the basis of the characteristics of the pistillate plants. Table 1[3] is a comparison of these two species without regard to sex.

TABLE 1

	D. stricta	*D. dentata*
Leaf width in mm.	1.5–3.5	1.5–4.0
Florets per spikelet	5–18	5–13
Width of spikelet in mm.	3.0–5.5	4–6
Length of spikelet in mm.	8–27	10–20
Width of lemma in mm.	1.5–2.2	1.8–2.5
Length of lemma in mm.	4.0–7.5	4.5–7.0

It will be noted that all the characters compared above, with the exception of "florets per spikelet," were used by Rydberg to separate *D. dentata* from *D. stricta*. Examination of table 1, however, shows that there is so much overlapping that these characters are not diagnostic.

Hitchcock (1935), in his key, separated *D. dentata* from *D. stricta* on the basis of the dentate palea-keels plus relative length of lemma to palea.[4] In his description he stated that the panicles of *D. dentata* are usually "overtopped" by the leaves. The following table is a comparison of staminate and pistillate plants regardless of the name on the label.

TABLE 2

	Staminate	Pistillate
Keels broadly winged	–	+
Keel wings prominently serrulate	–	+
Panicles exceeding the leaves	+	–

Examination of the paleas of the pistillate plants labeled *D. dentata* revealed that none of them is strictly dentate, while all are serrulate or serrulate-lacerate. This is also true for the pistillate plants labeled *D. stricta*. In both of these "species" the width of the keel varies from extremely wide to rather narrow, but the wing is always evident. In the staminate plants the palea-wings are entire or very slightly serrulate,[5] and are always narrower

[3] The data presented here represent a compilation of measurements made on all the specimens studied.

[4] In the Manual, *D. dentata* is said to have paleas longer than the lemmas, in contrast to *D. spicata* and *D. stricta* in which the lemmas exceed the paleas. However, Mrs. Agnes Chase, in a letter to the writer's wife, says that this is an error and that the two statements should be reversed, i.e., *D. dentata* has paleas shorter than the lemmas.

[5] Under a magnification of 20 diameters or more, in addition to serrulations, fimbriations may also be seen on the wing-margins in both staminate and pistillate plants.

than in pistillate plants (fig. 1). It was further noted that the paleas are shorter than the lemmas in practically all spikelets of the pistillate plants of the genus; while in the staminate plants the paleas are usually as long as, or longer than, the lemmas. Also the panicles of staminate plants usually exceed the leaves, while in pistillate plants the leaves commonly "overtop" the panicles (fig. 2). It is readily seen that these characters, which have been used to separate species, are merely distinctions between the sexes.

A very significant fact disclosed by this study is that 100 per cent of all sheets labeled *D. dentata* contained pistillate plants; while only 30 per cent

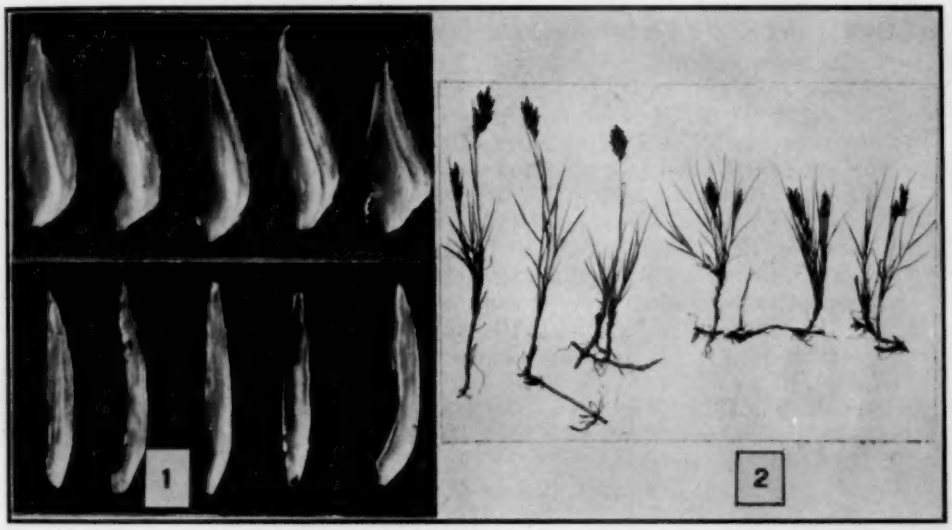

FIG. 1. Paleas of *Distichlis stricta* × 5. Pistillate above; note very wide keel-wings and prominent serrulations. Staminate below; note narrow keel-wings and almost total absence of serrulations. FIG. 2. *Distichlis stricta*. Staminate plants on the left; note that the panicle is borne well above the leaves. Pistillate plants on the right; note that the leaves exceed the panicle.

of those labeled *D. stricta* contained pistillate plants. Indeed the type specimen of *D. dentata* is pistillate, while that of *D. stricta* is staminate.

Staminate plants were rare on sheets labeled *D. dentata;* when they were present they differed in no essential character from those on sheets labeled *D. stricta*. On the other hand, 70 per cent of the sheets labeled *D. stricta* contained staminate plants alone. Pistillate plants on the sheets labeled *D. stricta* often have all the characters described for *D. dentata,* although the width of the keel is variable as previously mentioned. However, when plants having the characters of *D. dentata* have been observed in the field by the writer, staminate plants have predominated. On numerous occasions it has required patient search before pistillate plants could be found. In view of these facts it seems obvious that *D. dentata* has been segregated from *D.*

stricta solely on the basis of the character of the pistillate plants. In almost any collection the pistillate plants could readily be referred to *D. dentata* and the staminate to *D. stricta*. This evidence indicates that *D. dentata* Rydb. should be reduced to synonymy under *D. stricta* (Torr.) Rydb.

SPECIMENS EXAMINED

Specimens from the following herbaria have been consulted in making this study: United States National Herbarium, Washington, D. C. (US); Oregon State College, Corvallis, Oregon (OS); University of Oregon, Eugene, Oregon (UO); Rocky Mountain Herbarium, Laramie, Wyoming (RM); and New York Botanical Garden, New York (NY).

CALIFORNIA: *Hitchcock 2586* (♂), US; *Silveus 2855* (♂), US. COLORADO: *Johnson 1031* (♀), as *D. dentata*, US; *Rollins 1957* (♂), US. IDAHO: *Chase 4767* (♂ & ♀), as *D. dentata*, US; *C. P. Smith 1772* (♂), US. KANSAS: *Thompson 25* (♂), US. MINNESOTA: *Hotchkiss & Jones 3997* (♂ & ♀), US. MISSOURI: *Bush 6460* (♀), US. MONTANA: *Williams & Griffiths 233* (♂), US. NEBRASKA: *Clements 2840* (♀), US; *Hapeman* in 1926 (♂), OS; *Rydberg 1814* (♂ & ♀), US; *Thomson 335* (♀), US. NEVADA: *Heller 10558* (♂ & ♀), as *D. dentata*, US; *Tidestrom 10147* (♂ & ♀), as *D. dentata*, US; *Train 2192* (♀), as *D. dentata*, US. NEW MEXICO: *Hardies* in 1936 (♀), US; *Dr. James*, sources of the Canadian (♂), (TYPE), NY. NORTH DAKOTA: *Hitchcock 5059* (♂), US; *Lunnell* in 1913 (♀), US. OKLAHOMA: *Clemens 11489* (♀), US; *Stevens 660* (♂), US. OREGON: *Anderson* in 1935 (♂), UO; *Cusick 1948* (♂ & ♀), UO; *Elder 143* (♂ & ♀), as *D. dentata*, US; *Fleischman* in 1934 (♀), OS; *Gilkey* in 1932 (♂ & ♀), OS; *Griffiths & Morris 504* (♂), US; *Henderson 8172* (♀), UO; *Ingram B673* (♂ & ♀), OS; *Ingram* in 1917 (♀), OS; *Johnson* in 1932 (♂), OS; *Kuehner* in 1927 (♂), OS; *Leiberg 463* (♀), UO; *712* (♂), US; *712* (♂ & ♀), UO; *2387* (♀), as *D. dentata*, US; *Parsell 269* (♂), OS. SOUTH DAKOTA: *Griffiths 355* (♀), US; *202* (♂), US; *Wallace 6* (♂), US. UTAH: *Garrett 5201* (♀), as *D. dentata*, US; *Harrison 293* (♂), US. WASHINGTON: *Elmer 508* (♀), as *D. dentata*, US; *Leckenby* in 1898 (♂), US; *Sandberg & Leiberg 251* (♂), US; *463* (♀), as *D. dentata*, US & RM (TYPE of *D. dentata* at NY); in 1893 (♀), as *D. dentata*, RM; *Sprague* in 1938 (♀), OS; *Vasey 4* (♂), US. WYOMING: *Merrill 12* (♂ & ♀), US; *Nelson 8175* (♂), US.

SUMMARY

Study of numerous collections of *Distichlis* from 17 western states shows that *D. dentata* is not distinct from *D. stricta*. These two "species" cannot be separated on the basis of staminate plants and only arbitrarily on the basis of pistillate plants. The basis for segregation of *D. dentata* has apparently been the characters of the pistillate plants, as no single collection of staminate plants has been referred to this species. *D. dentata* is reduced to a synonym of *D. stricta*.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 58–61 JANUARY, 1943

NEW NORTH AMERICAN UMBELLIFERAE—II

MILDRED E. MATHIAS AND LINCOLN CONSTANCE

Tauschia Johnstoniana Mathias & Constance, sp. nov. Herba acaulescens caespitosa, 10–15 cm. alta, scabrida vel scaberula; folia in ambitu oblonga vel ovata, petiolo excluso 2–6.5 cm. longa, 2–4 cm. lata, pinnata vel pro parte bipinnata, foliolis linearibus oppositis distinctis, 5–40 mm. longis, 1–1.5 mm. latis, integris mucronatis; petioli 3–5 cm. longi infra anguste scarioso-marginati; pedunculi 7–9 cm. longi, folia aequantes vel excedentes; involucri bracteae 1–2, lineares; involucellae bracteolae plures lineares, 1–5 mm. longae, circa flores aequantes, fructu breviores; radii fertiles 3–5, subaequales, 10–15 mm. longi scaberuli; pedicelli circa 1 mm. longi; flores lutei; styli tereti graciles recurvati; fructus ovalis circa 5 mm. longus, 2–3 mm. latus, commissurae apice alte excavata, costis filiformibus; vittae parvae in intervallis atque in commissura plures; seminis facies sulcata.

Acaulescent, caespitose, 10–15 cm. high, the foliage and inflorescence scabrous or scaberulous; leaves oblong to ovate in general outline, excluding the petiole 2–6.5 cm. long, 2–4 cm. broad, pinnate to partially bipinnate, the leaflets linear, opposite, distinct, 5–40 mm. long, 1–1.5 mm. broad, entire, mucronate; petioles 3–5 cm. long, narrowly scarious-margined below; peduncles 7–9 cm. long, equalling to exceeding the leaves; involucre of 1–2 linear bracts; involucel of several linear bractlets, 1–5 mm. long, about equalling the flowers but shorter than the fruit; fertile rays 3–5, subequal, 10–15 mm. long, scaberulous; pedicels about 1 mm. long; flowers yellow; styles terete, slender, recurved; fruit oval, about 5 mm. long, 2–3 mm. broad, with a V-shaped depression at the commissure, the ribs filiform; oil tubes small, several in the intervals and on the commissure; seed face sulcate.

TYPE: *Stanford, Retherford & Northcraft 682,* on mountain top 7 kilometers southwest of Miquihauana, Tamaulipas, Mexico, alt. 3430 m., August 5, 1941 (UC, TYPE; GH, isotype). Although it fully agrees with the chief generic characters, this very striking species does not seem to possess any close relatives. In our key it appears variously next to *T. Ehrenbergii* (Wolff) Mathias, *T. Stricklandi* (Coult. & Rose) Mathias & Constance and *T. texana* Gray, but these juxtapositions may be due fully as much to chance as to consanguinity. The species is named in honor of Dr. Ivan M. Johnston, of Harvard University, who is the author of some excellent critical studies of American Umbelliferae, and who correctly placed the present entity in the proper genus.

Lomatium idahoense Mathias & Constance, sp. nov. Plantae aculescentes vel brevi-caulescentes, 2–4 dm. altae, e radice prima gracile; caules graciles glabri; folia pauca glabra in ambitu obovata, petiolo excluso 4–12 cm. longa, ternato-pinnata vel pro parte biternata, divisionibus ultimis anguste linearibus vel oblongis acutis obtusisve, 1–10 cm. longis, 1–4 mm. latis; petiolus glaber, 1.5–12 cm. longus, parte inferiora (0.3–0.6 cm.) anguste vaginante; involucella nulla; radii 3–7 adscendentes, 2–8 cm. longi, inaequales graciles; pedicelli filiformes, 5–15 mm. longi; umbellularum flores 7–20 lutei; fructus glaber anguste oblongus ad apicem acutus, 10–12 mm. longus, 3–4 mm.

latus, alis quam corpore multo angustioribus; vittae in intervallis solitariae, in commissura 2.

Plants caulescent or short-caulescent, 2–4 dm. high, from a long, slender taproot, the stems slender, few-leaved, glabrous; leaves obovate in general outline, excluding the petiole 4–12 cm. long, ternate-pinnate or partially biternate, the ultimate divisions narrowly linear to oblong, acute or obtuse, 1–10 cm. long, 1–4 mm. broad, glabrous; petiole 1.5–12 cm. long, narrowly sheathing in the lower one- or two-thirds, glabrous; involucel wanting; rays 3–7, ascending, 2–8 cm. long, unequal, slender; pedicels filiform, 5–15 mm. long, the umbellets 7–20-flowered; flowers yellow; fruit narrowly oblong, acute at the apex, 10–12 mm. long, 3–4 mm. broad, glabrous, the wings much narrower than the body; oil tubes solitary in the intervals, 2 on the commissure.

TYPE: *A. H. Cronquist 2856*, gravelly granitic hillside along Beaver Creek near Marsh Creek, 25 miles northwest of Stanley, Custer County, Idaho, alt. 6400 feet, July 3, 1941 (UC, TYPE; IM, MB, MINN, UIs, isotypes).

Specimens examined: IDAHO: Beneath *Pseudotsuga taxifolia* and *Pinus ponderosa* on ridge above east side of Sheep Creek, Idaho County, alt. 5500 feet, May 11, 1939, *F. G. Meyer 1614* (MEYER, UC); moist talus on hills above Sheep Creek and the Snake River Canyon, Canadian Zone, May 16, 1936, *F. G. Meyer 262a* (MEYER); Panther Creek, Lemhi County, May 16, 1941, *Ray J. Davis 3113* (UC, UIs); ½ mile below Middle Fork, Lemhi County, May 15, 1941, *Ray J. Davis 3060* (UC, UIs).

The discovery of such novelties as this bears witness to the fact that Idaho is perhaps the least fully explored of any of the continental United States. *Lomatium idahoense* appears to be most closely related to *L. laevigatum* (Nutt.) Coult. & Rose, a species of the Columbia River Valley, in Washington and Oregon. It differs, however, from *L. laevigatum* in its many fewer leaflets, fewer rays and longer and more slender fruit.

Lomatium Rollinsii Mathias & Constance, sp. nov. Plantae graciles caulescentes alterne ramosae, 2.5–5 dm. altae, e radice prima elongata saepe tuberosa, omnino crispo-puberulae; folia in ambitu oblonga, petiolo excluso 5–15 cm. longa, 3–5 cm. lata, bipinnata vel pro parte tripinnata, divisionibus ultimis linearibus acutis obtusisve, 0.2–3 cm. longis, 0.5–2 mm. latis, puberulis; petiolus basilaris, 5–15 cm. longus, ad basim anguste brevi-vaginans, caulini prorsi anguste vaginantes; involucellae bracteolae minutae filiformes; radii 4–8, adscendentes, 1.5–5 cm. longi, inaequales graciles puberuli; pedicelli filiformes, 6–15 mm. longi; umbellularum flores 8–15 lutei; fructus oblongo-ovatus, 6–7 mm. longus, 3–4 mm. latus, glaber, alis quam corpore dimidio angustioribus; vittae in intervallis dorsalibus solitariae, in lateralibus 2, in commissura 4.

Plants slender, caulescent, alternately branched, 2.5–5 dm. high, from an elongated and often tuberous taproot, crisped-puberulent throughout; leaves oblong in general outline, excluding the petiole 5–15 cm. long, 3–5 cm. broad, bipinnate or partially tripinnate, the ultimate divisions linear, acute or obtuse, 0.2–3 cm. long, 0.5–2 mm. broad, puberulent; petiole 5–15 cm. long, narrowly short-sheathing at base, those of the cauline leaves narrowly and wholly sheathing; involucel of minute, filiform bractlets; rays 4–8, ascending, 1.5–5 cm. long, unequal, slender, puberulent; pedicels filiform, 6–15 mm.

long, the umbellets 8–15 flowered; flowers yellow; fruit oblong-ovate, 6–7 mm. long, 3–4 mm. broad, glabrous, the wings one-half the width of the body; oil tubes solitary in the dorsal intervals, 2 in the lateral, 4 on the commissure.

TYPE: *Constance, Rollins & Dillon 1573*, grassy dry soil, near Deep Creek, Snake River Canyon, Wallowa County, Oregon, alt. 1000 feet, May 15, 1936 (UC, TYPE; distributed to other herbaria as *Cogswellia ambigua* (Nutt.) Jones).

Specimens examined: IDAHO: Stony soils in wheat-farming area 7 miles north of Waha, Nez Perce County, April 25, 1940, *J. H. Christ 10,877* (CHRIST, UC); on rolling hills 2 miles west of Webb, Nez Perce County, April 25, 1940, *J. H. Christ 10,889* (CHRIST, UC); on rocky hillside, Slate Creek, Salmon River Canyon, Idaho County, May 16, 1937, *J. H. Christ & W. W. Ward 7300* (CHRIST, UC), May 21, 1939, *J. H. Christ s. n.* (UC). OREGON: Basalt outcroppings on hills above the Snake River in the Snake River Canyon, Upper Sonoran Zone, Wallowa County, May 15, 1936, *F. G. Meyer 231* (MEYER).

This species adds to the growing list of plants believed to be endemic to the drainage area of the Snake and Salmon rivers. *Lomatium Rollinsii* superficially resembles *L. ambiguum* (Nutt.) Coult. & Rose, chiefly because of the mode of branching combined with the color of the flowers. The two are very probably related, but the newly detected species differs from *L. ambiguum* in being puberulent instead of glabrous, having pinnately instead of ternate-pinnately divided leaves and ovate-oblong rather than oblong fruit. The species is named for Dr. Reed C. Rollins, of Stanford University, who accompanied the junior author upon several noteworthy botanical investigations of the Snake River Canyon.

The following abbreviations for herbaria are used in this paper: Gray Herbarium, Harvard University (GH); Intermountain Herbarium, Utah State Agricultural College (IM); Missouri Botanical Garden (MB); Herbarium, University of Minnesota (MINN); University of California Herbarium, Berkeley (UC); Herbarium, University of Idaho, Southern Branch, Pocatello (UIs).

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, No. 1, pp. 61–67 JANUARY, 1943

NOMENCLATURAL CHANGES IN THE GENUS CUSCUTA, AND NOTES ON SOME AMERICAN SPECIES

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In volume 18 of the Memoirs of the Torrey Botanical Club, I published in 1932 a comprehensive review of all of the species of *Cuscuta* then known. Since the appearance of this paper I have examined a large number of additional specimens, some of which have proved to be new species. These have been published from time to time. Several errors, some involving rules of nomenclature, have also been discovered in the above-mentioned paper. Corrections of these errors together with the presentation of additional notes which have accumulated on a number of species are given in the following discussion.

CUSCUTA HARPERI Small, Flora S. E. U. S. ed. 2, 1361, 1913. This is one of the smallest and most inconspicuous of our American species, with flowers mostly 1 mm. or less long. It appears to enjoy a very local distribution limited to a few counties in the states of Georgia and Alabama. It was collected in Washington County, Georgia, between Peacocks and Harrison, July 20, 1906, by R. M. Harper, and also 3 miles north of Harrison in the same county, June 10, 1938, by J. H. Pyron and R. McVaugh (*3102*). Harper recognized the specimen he had found as probably new to science and reported it in his paper entitled "Some hitherto undescribed outcrops of Altemaha grit and their vegetation" in Torreya for December 1906. In Alabama it had been found at DeSoto Falls, Lookout Mountain, July 1898, by Albert Ruth (*473*); in the vicinity of Gadsen, Etowah County, July 29, 1900, by Pollard and Maxon (*341*); and in a rocky glade on the west side of Short Creek on Sand Mountain about 5 miles northeast of Boaz, Marshall County, August 29, 1933, by R. M. Harper (*3107*).

In each of the above specimens the host, when indentifiable, is *Chondrophora virgata* (Nutt.) Greene, with the exception of Harper's *3107* which is on *Helianthus longifolius* Pursh and *Laciniaria microcephala* Small. The host as indicated on the label for Pollard and Maxon's *341* was *Chondrophora nudata* (Michx.) Britton. In commenting on this host, however, R. M. Harper in a recent communication states "They were certainly in error in calling the host plant *Chondrophora nudata* for that species is not known outside of the coastal plain."

The type specimen for this species, as indicated by Small on page 1375 of his Flora, is the one collected by Harper in Washington County, Georgia, July 20, 1906. There are two sheets of this collection in the New York

Botanical Garden herbarium, one of which has been selected to represent the type. In error, I formerly listed Harper's *147* as the type collection.

CUSCUTA PAUCILFLORA Philippi, Linnaea **33**: 185. 1864. *C. pusilla* Philippi ex Yuncker, Mem. Torrey Club **18**: 151. 1932.

At the time the description of *C. pusilla* was published no authentic material of *C. pauciflora* had been seen, but from Philippi's original description it was decided that *C. pauciflora* was probably the same as *C. micrantha* Choisy, with which species it was questionably allied as a synonym. More recently, I. M. Johnston has loaned from Gray Herbarium a fragment of what is presumably the type of *C. pauciflora* which was collected by Philippi on *Myrtus nummularia* at Ancud, Chile, January 1858. This specimen is very fragmentary, but after carefully comparing it with the specimen upon which the description of *C. pusilla* was based, collected also by Philippi somewhat farther north at Valdivia, it now appears evident that they are the same.

C. pauciflora is distinguished with some difficulty from *C. micrantha* Choisy, another Chilean species which commonly occurs on low herbaceous hosts. The flowers of both are small, measuring about 1.5 mm. from the base up to the corolla sinuses. *C. pauciflora*, however, appears to have much longer pedicels, proportionately longer corolla lobes, more campanulate corollas, and more globose ovaries. On the basis of the specimens which have been examined *C. micrantha* also appears to have a more northern distribution.

CUSCUTA INDECORA Choisy, Mém. Soc. Phys. Hist. Nat. Genève **9**: 278. *pl. 3. f. 3.* 1841. *C. hispidula* Engelmann, Am. Jour. Sci. **45**: 75. 1843. *C. neuropetala* Engelmann, Am. Jour. Sci. **45**: 75. 1843. *C. neuropetala* Engelmann var. *littoralis* Engelmann, Bost. Jour. Nat. Hist. **5**: 223. 1845. *C. pulcherrima* Scheele, Linnaea **21**: 750. 1848. *C. decora* Englemann, Trans. Acad. St. Louis **1**: 501. 1859. *C. decora* Engelmann var. *indecora* (Choisy) Engelmann, Trans. Acad. St. Louis **1**: 502. 1859. *C. decora* Engelmann var. *pulcherrima* (Scheele) Engelmann, Trans. Acad. St. Louis **1**: 502. 1859. *C. indecora* Choisy var. *neuropetala* (Engelmann) Hitchcock, Contrib. U. S. Nat. Herb. **3**: 549. 1896.

At the time Engelmann monographed the genus *Cuscuta* (Trans. Acad. St. Louis, 1859) he replaced Choisy's earlier epithet *indecora* with his *decora* which he considered as being more appropriate, and at the same time distinguished four varieties. His variety *indecora*, which was the typical variety and the same as Choisy's species *indecora*, was characterized as having small flowers, short calyx lobes, and long pedicels. Engelmann also included under this variety a form with very hispid-papillate flowers which he had formerly described with the specific name *hispidula*.

His variety *pulcherrima* was the same as *C. neuropetala*, previously described by him together with its variety *littoralis*, and also as Scheele's

C. pulcherrima. This variety is characterized as having larger, smooth or nearly smooth flowers, with proportionately larger calyx. If this variety were to be maintained it should, according to the International Rules, retain the older epithet *littoralis* rather than the later *pulcherrima*.

I have examined many specimens of *C. indecora* collected throughout the range of the species and have found the various characters which Englemann used to distinguish variety *pulcherrima* from variety *indecora*, or the typical variety, to be exceedingly variable. The size of the flowers, the length of the pedicels and the proportionate size of the calyx vary greatly, sometimes even on the same specimen. Most of the flowers are more or less granulate because of the lenticular outer surface of the cells and occasional specimens are even papillate-hispid. There is, however, no observed constancy in the shape and degree of protrusion of the outer walls of the cells. In view of the inconstancy of any of the characters used by Engelmann to distinguish the two varieties under discussion, I have come to the conclusion that it would be better not to attempt to maintain them as separate entities.

CUSCUTA SUKSDORFII Yuncker, Mem. Torrey Club **18**: 167. f. 41. 1932.

This species was originally described from a specimen collected on *Aster* in Skamania County, Washington, in 1891 by Suksdorff (*1487*). It was also found 10 miles southeast of Port Orford, Curry County, Oregon, in 1919 by M. E. Peck (*8624*). In 1934 L. C. Wheeler collected two specimens on *Calyptridium umbellatum* above 6000 feet in the Siskiyou Mts., Siskiyou County, California (*3011; 3192*). These two specimens differed from the species in certain characters and were described as new under the varietal epithet of *subpedicellata* Yuncker (Bull. Torrey Club **62**: 512. 1935). A specimen collected at Bluff Lake, at 7400 feet altitude, in the San Bernardino Mts., San Bernardino County, California, July 13, 1926, by P. A. Munz (*10678*) has recently come to my attention. In this specimen the pedicels are exceptionally long and a number of the flowers were discovered which lacked infrastamineal scales. In a few flowers, however, two or three small lateral projections representing greatly reduced scales were observed along the filament attachment line. Otherwise this plant closely resembles those from the north. This specimen from southern California may possibly represent a different variety. This can be determined, however, only upon the study of additional and more abundant material from this region. Plants of this species are inconspicuous and are to be sought at altitudes of 6000 feet or more.

CUSCUTA NEVADENSIS Johnston, Proc. Calif. Acad. IV **12**: 1133. 1924. *C. Veatchii* Brandegee var. *apoda* Yuncker, Ill. Biol. Monogr. **6**: 159. 1921. *C. salina* Engelmann var. *apoda* (Yuncker) Yuncker, Mem. Torrey Club **18**: 169. 1932.

Considerable trouble has been encountered in attempting to determine the correct taxonomic status of this species. I described it originally as a variety of *C. Veatchii*. Johnston later questioned its relationship to *C. Veatchii* and gave it the specific name of *C. nevadensis*. In 1932 I further complicated the nomenclature by transferring it to varietal status under *C. salina*, to which some specimens of it bear considerable resemblance. In a specimen recently studied, matured seeds were discovered for the first time. In these seeds the embryo was found to be similar to those characteristic of *C. denticulata* and *C. Veatchii*, in both of which species it exhibits an abruptly enlarged ball-like end. This character, so far known to exist only in these three species, distinguishes it from *C. salina* which possesses the more slender embryo typical of most species of *Cuscuta*. It differs from *C. Veatchii*, with which it is most likely to be confused, by having larger flowers, mostly longer pedicels, proportionately longer calyx and corolla lobes, and larger anthers on short filaments. I now agree with Johnston in considering it sufficiently different to be considered as of specific rank.

CUSCUTA GRONOVII Willdenow var. LATIFLORA Engelmann, Trans. Acad. St. Louis **1**: 508. 1859. *C. Gronovii* Willdenow var. *Saururi* (Engelmann) MacMillan, Metasp. Minn. 430. 1892.

C. Gronovii is the commonest species of dodder occurring in the central and northeastern United States and Canada. It extends southward to the gulf states, and sparingly even to the West Indies, and westward nearly to the Rocky Mountains. It does not appear to be particular as to hosts although it occurs most commonly on species, either woody or herbaceous, which grow in low, moist areas.

The specimen numbered *3160* in Willdenow's herbarium, taken as probably representing the type, has flowers which are approximately 2 mm. long from the base up to the corolla sinuses. The calyx lobes are oval-ovate, overlapping at the base and reaching to about the middle of the corolla tube which is campanulate with the sides subparallel above the center as viewed laterally. This is the variety most commonly found. The size of the flowers has been found to vary from a minimum of about 1 mm. up to 2.5 or even 3 mm. in length from the base up to the corolla sinuses. In some specimens the throat of the corolla may be narrower than the tube at the middle because of the maturing fruit; and occasional specimens may, on the contrary, exhibit somewhat funnel-form corollas. The shape of the corolla determines its position about the capsule which is commonly enveloped by the corolla when matured.

In variety *latiflora* the flowers are usually smaller. The calyx lobes are more oblong-oval and less overlapping at the base, and they reach the corolla sinuses. The corolla tube is broadly campanulate with the throat wider than

the tube which tapers towards the base. Because of its shape, the corolla is ordinarily borne at the base of the protruding, naked capsule when mature. In this variety there is also a greater tendency to produce the inflorescence endogenously. The inflorescence is also commonly more branched than for the species in general and in occasional specimens a "witches' broom" effect is produced which arouses the suspicion that there may be an unfavorable influence of the host upon the parasite.

Engelmann's varietal name *latiflora* is to be retained as valid under the International Rules. The variety occurs throughout the range of the species and appears, as in the case of the typical variety, to show no host preferences.

CUSCUTA UMBROSA Hooker, Fl. Bor. Am. **2**: 78. 1840. *C. Gronovii* Willdenow var. *curta* Engelmann, Trans. Acad. St. Louis **1**: 508. 1859. *C. megalocarpa* Rydberg, Bull. Torrey Club **28**: 501. 1901. *C. curta* (Engelmann) Rydberg, Bull. Torrey Club **40**: 466. 1913.

As has been pointed out by Engelmann, *C. umbrosa* Hooker included specimens now recognized as belonging both to *C. Gronovii* and to this species. According to Section 8, Article 52, of the International Rules, Hooker's name must be retained for one of the segregated species.

CUSCUTA COMPACTA Jussieu var. EFIMBRIATA Yuncker, Ill. Biol. Monogr. **6**: 167. 1921.

This variety, characterized by greatly reduced infrastamineal scales, was known originally only from the type specimen collected by Fredholm in Duval County, Florida. Professor Delzie Demaree found the second known specimen of it near Tillar in Desha County, Arkansas, October 24, 1936 (*14051*).

CUSCUTA GRANDIFLORA H.B.K., Nov. Gen. Sp. Pl. **3**: 123. *pl. 213.* 1818.

This is one of the most widely distributed of the South American highland species, ranging from Colombia to Chile and Argentina. It is easily recognized because of its large, attractive flowers which lack infrastamineal scales. There is considerable variation in the shape and length of the styles. Typically, the styles range up to about 1 mm. in length, are slightly flattened and taper gradually to a wider base. Occasional specimens, however, have the styles strongly flattened, and in one or two specimens examined one of the styles was found to be much longer than the other. A specimen collected by E. K. Balls in the Department of Cochabamba, Bolivia, at 11,000 feet altitude, March 15, 1939 (*6238*), has both styles much shorter than any hitherto seen for this species. The contrast is sufficiently great to suggest recognition with formal or varietal status. Because of the variation already noted in the styles of this species, however, it is believed better not to describe it as new at present from the single specimen at hand.

CUSCUTA FLOSSDORFII Hicken, Darwiniana **1**: 31. 1922. *C. brevisquamata* Yuncker, Am. Jour. Bot. **9**: 566. *pl. 1, f. 1a–e.* 1922.

This distinctive Argentina species was described under the above two names almost simultaneously in 1922. As nearly as could be determined from the original description and without having seen the type, it was decided later that *C. Flossdorfii* was closely related to *C. brevisquamata* and in 1932 I tentatively placed it as synonymous with that species.

Recently, through the kindness of Dr. Arturo Burkart, director of the Instituto de Botanica Darwinion, I have had an opportunity of examining the type of *C. Flossdorfii* and discover that it is identical with *C. brevisquamata.* I also discover that the publication of *C. Flossdorfii* occurred a short time before that of *C. brevisquamata* and, hence, has priority.

The type of *C. Flossdorfii,* now in the herbarium of the Instituto de Botanica Darwinion, was collected on *Satureia eugenioides* by A. Flossdorf in the Province de La Rioja, Argentina, February, 1913, at 3000–4000 meters altitude. A specimen collected by Schreiter (*3057*) in the Province of Tucuman has also been seen.

CUSCUTA JAPONICA Choisy var. THYRSOIDEA Engelmann, Trans. Acad. St. Louis **1**: 517. 1859. *C. formosana* Hayata, Icon. Plant. Formos. **2**: 124. *pl. 30.* 1912. *C. japonica* Choisy var. *formosana* (Hayata) Yuncker, Mem. Torrey Club **18**: 253. 1932.

Engelmann gave the name of *thrysoidea* to variety *a* or the typical variety of *C. japonica.* Later, Hayata gave a large-flowered specimen of *C. japonica* the name of *C. formosana.* In studying *C. japonica,* I concluded that Hayata's plant differed from the typical form in certain features and decided that it should be retained as a variety. Part of the specimens listed by Engelmann as belonging to variety *thyrsoidea* also appeared to belong to the new variety as established. Thus, part of variety *thyrsoidea,* as recognized by Engelmann, remained representative of the typical variety or species and part became the variety which I listed as variety *formosana.* However, according to section 8, article 52, of the International Rules, Engelmann's earlier name should be retained for the variety rather than Hayata's later epithet.

The following nomenclatural corrections are required, for the most part, under article 58 of the International Rules:

CUSCUTA AUSTRALIS R. Brown var. **breviflora** (Visiani) Yuncker, comb. nov. *C. australis* R. Brown var. *Tinei* (Insenga) Yuncker, Mem. Torrey Club **18**: 126. 1932.

CUSCUTA RACEMOSA Martius var. MINUTA Choisy, Mém. Soc. Phys. Hist. Nat. Genève **9**: 277. 1841. *C. racemosa* Martius var. *miniata* Engelmann, Trans. Acad. St. Louis **1**: 505. 1859.

CUSCUTA REFLEXA Wallich var. BRACHYSTIGMA Engelmann, Trans. Acad.

St. Louis **1**: 519. 1859. *C. reflexa* Wallich var. *anguina* (Edgeworth) Yuncker, Mem. Torrey Club **18**: 260. 1932.

CUSCUTA CAPILLARIS Reichenbach, Icon. Bot. **5**: 64. 1827. *C. palaestina* Boissier, Diagn. Pl. Or. Nov. I. **2**[11]: 86. 1849.

CUSCUTA CAPILLARIS Reichenbach var. **syriana** (Yuncker) Yuncker comb. nov. *C. palaestina* Boissier var. *syriana* Yuncker, Mem. Torrey Club **18**: 280. 1932.

CUSCUTA EPITHYMUM Murray var. ANGUSTATA Engelmann, Trans. Acad. St. Louis **1**: 463. 1859. *C. Epithymum* Murray var. *alba* (Presl) Trabut, Bull. Soc. Bot. France **53**: xxxvii. 1907.

CUSCUTA PLANIFLORA Tenore var. **subpapillosa** (Trabut) Yuncker comb. nov. *C. planiflora* Tenore var. *Godronii* (DesMoulin) Rouy, Flore de France **10**: 359. 1908.

CUSCUTA APPROXIMATA Babington var. **Webbii** (Engelmann) Yuncker comb. nov. *C. approximata* Babington var. *Episonchum* (Webb & Berthelot) Yuncker, Mem. Torrey Club **18**: 299. 1932.

In addition, errors have been detected in the form of citation of some names. These names are correctly cited as follows: *Cuscuta cordofana* (Engelmann) Yuncker, comb. nov. *Cuscuta brachycalyx* (Yuncker) Yuncker, comb. nov. *Cuscuta xanthochortos* Martius var. *carinata* (Yuncker) Yuncker, comb. nov. *Cuscuta foetida* H. B. K. var. *pycnantha* (Bentham) Yuncker. *Cuscuta corymbosa* Ruiz & Pavon var. *stylosa* (Choisy) Engelmann. *Cuscuta potosina* Schaffner apud Watson. *Cuscuta potosina* Schaffner var. *globifera* Yuncker. *Cuscuta saccharata* (Engelmann) Yuncker, comb. nov. *Cuscuta Epithymum* Murray var. *angustissima* (Engelmann) Yuncker, comb. nov. *Cuscuta Balansae* Boissier & Reutter ex Yuncker. *Cuscuta Balansae* Boissier & Reutter ex Yuncker var. *socotrensis* Yuncker, var. nov. *Cuscuta approximata* Babington var. *leucosphaera* (Boissier & Heldreich) Yuncker, var. nov.

I wish to thank Dr. H. W. Rickett, bibliographer of the New York Botanical Garden, for assistance in checking and verifying nomenclatural data used in the preparation of this paper.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 70, NO. 1, PP. 68–81 JANUARY, 1943

DESCRIPTIONS OF TROPICAL RUSTS—V[1]

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The Uredinales reported in this paper were collected, for the most part, by Paul C. Standley of the Field Museum of Natural History, during his trip to Guatemala in 1940 and 1941. He obtained 562 specimens of rusts but only those of more than ordinary interest are reported here. A few collections made by Julian A. Steyermark and John R. Johnston are also included. All specimens are from Guatemala. The type specimens are deposited in the Arthur Herbarium, Purdue University Agricultural Experiment Station. Specimens collected by Standley are also in the Field Museum of Natural History.

AECIDIUM TALINI Speg. On *Talinum triangulare* (Jacq.) Willd., Dept. SANTA ROSA: along the Avellana road south of Guazacapán, December 6, 1940, *Standley 79497*.

A portion of this collection was sent to Dr. Juan C. Lindquist who kindly compared it with material from La Viña, Salta, Argentina, which had been named by Spegazzini. He found it to agree in all respects. The species has not been reported before from North America.

AECIDIUM FUCHSIAE Jacks. & Holw. On *Fuchsia minutiflora* Hemsl., Dept. CHIMALTENANGO: Las Calderas, June 21, 1941, *Johnston 1912*.

A. fuchsiae has not been reported from North America previously and Johnston's specimen does not show complete agreement. The peridia are somewhat paler than typical and the wall of the aeciospores is thinner. For the present, however, it seems advisable to report this collection as *A. fuchsiae*.

Aecidium lycianthis Cummins, sp. nov. Pycniis non visis. Aeciis hypophyllis subepidermalibus, in maculis irregularis flavidis usque ad 2 cm. longis aggregatis, vel petiolicolis vel caulicolis, breviter cupulatis vel bullatis, pallide flavidis, 150–300 μ diam., margine lacerato vel eroso; cellulis peridii oblongis vel oblongo-ellipsoideis, 14–16 × 23–32 μ, pariete interiore verrucoso 2 μ cr., verrucis plus minusve elongatis, exteriore striato 3–3.5 μ cr.; aeciosporae ellipsoideae vel oblongae, 12–17 × 17–24 μ; membrana hyalina, 1.5–2 μ cr., minuteque verrucosa.

On *Lycianthes quichensis* (Coult. & D. Sm.) Bitter, Dept. CHIMALTENANGO: Las Calderas, November 5, 1940, *Johnston 1708*, June 21, 1941, *Johnston 1877* (TYPE); Dept. QUEZALTENANGO: Aguas Amargas, on the western slope of Volcán de Zunil, January 14, 1941, *Standley 83365*.

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[1] Journal Paper Number 27, of the Purdue University Agricultural Experiment Station. Contribution from the Department of Botany. The fourth article of this series was published in Bull. Torrey Club **68**: 467–472. 1941.

This rust is variable in habit. No hypertrophy is evident on the leaf blades but when the petioles and stems are infected there is some hypertrophy and distortion. In one specimen there are a few aecia on two flower buds, so it is not improbable that fruits may also be susceptible to infection.

There has been no previous account of a rust on *Lycianthes*.

Aecidium dahliae-maxoni Cummins, sp. nov. Pycniis nullis. Aeciis hypophyllis, subepidermalibus, in greges 1–3 mm. diam. laxe aggregatis, sine maculis, 0.1–0.2 mm. diam., cupulatis, pallide flavidis, margine recurvato; cellulis peridii firme conjunctis, oblongis vel polyhedricis, 16–22 × 25–35 μ, pariete interiore moderate verrucoso 2–2.5 μ cr., exteriore minuteque punctato-striato 3–4 μ cr.; aeciosporae late ellipsoideae vel globoideae, 14–18 × 17–20 μ; membrana hyalina, 0.5–1 μ cr., minuteque verruculosa.

On *Dahlia maxonii* Saff., Dept. CHIMALTENANGO: Las Calderas, June 21, 1941, *Johnston 1875*.

Microscopically this species is much like *A. dahliae* Syd. but it is entirely different macroscopically because of the loosely grouped aecia. There are frequently only four or five aecia in a group and seldom more than twelve, whereas the aecia are numerous and densely grouped in Sydow's species. The absence of pycnia and the almost total absence of discoloration around the aecia provide additional differences.

ANGIOPSORA LENTICULARIS Mains. On *Panicum arundinariae* Trin., Dept. CHIMALTENANGO: along Río Guacalate, southeast of Chimaltenango, December 14–23, 1940, *Standley 81037*.

Previous collections of *A. lenticularis* have all been on species of *Lasiacis*. Both uredia and telia are present in Standley's collection and both agree too well with those of *A. lenticularis* to permit reference to either a new species or any other described species of *Angiopsora*. *A. lenticularis* has been collected in Guatemala on *Lasiacis*.

ANGIOPSORA PALLESCENS (Arth.) Mains. On *Euchlaena mexicana* Schrad., GUATEMALA CITY, Jardín Botánico, May 1, 1941, *Standley 92861*.

Telia are not present in this collection but the uredia and urediospores agree with those of *A. pallescens*, a species which had been collected previously only on the genus *Tripsacum*. On the basis of the relationship of the hosts one might expect that *Euchlaena* would also be susceptible to *Angiopsora zeae*.

BAEODROMUS HOLWAYI Arth. On *Senecio warscewiczii* A. Br. & Bouché, Dept. QUEZALTENANGO: region of Los Alonzo, mts. above San Juan Ostuncalco, January 21, 1941, *Standley 84176*.

This specimen, which is only scantily infected, provides the first Guatemalan record for the species. It is known otherwise only from Nevada de Toluca, Mexico, where Holway collected it on *Senecio cinerarioides* in 1903.

BUBAKIA MEXICANA Arth. On *Croton draco* Schlecht., Dept. JUTIAPA: between Jutiapa and Las Tunas, northwest of Jutiapa, November 4, 1940, *Standley 76291*; on *Croton payaquensis* Standl., Dept. JUTIAPA: vicinity of Jutiapa, October 24–November 5, 1940, *Standley 75225*.

This rust, which is characterized by the apically thickened walls of the urediospores, has not been found previously in Guatemala or on either of the above cited hosts. *B. mexicana* is known from three Mexican collections on *C. calvescens, C. ciliato-glandulosa* and an undetermined species.

CEROTELIUM FICI (Cast.) Arth. On *Morus insignis* Bur. ?, Dept. CHIMALTENANGO: along Río Guacalate, southeast of Chimaltenango, December 14–23, 1940, *Standley 79987*.

There has been no previous record of a rust occurring on *Morus* in North America, although *C. fici* has been collected on *Morus indica* in the Orient and on related genera of hosts in the Americas.

CHRYSOMYXA PYROLAE (DC.) Rostr. On *Pyrola secunda* var. *elatior* Lange, Dept. QUEZALTENANGO: Volcán Zunil, January 22, 1940, *Steyermark 34776*.

Since *C. pyrolae* has not before been found south of the mountains of New Mexico this collection is of more than ordinary interest from the standpoint of distribution. The collection was made at an elevation of 2500–3800 meters. Mr. Standley has informed me that *Picea*, the alternate host genus, is not present in Guatemala.

CUMMINSIELLA STANDLEYANA Cumm. On *Berberis fascicularis* (DC.), Dept. HUEHUETENANGO: Sierra de los Cuchumatanes, along road beyond La Pradera, km. 32, December 31, 1940, *Standley 81803, 81819a*.

Old aecia as well as uredia and telia are present on no. 81803 while aecia are present on no. 81819a, which was separated from no. 81819, *Puccinia berberidis-trifoliae* Diet. & Holw. None of the aecia are in good condition for study but a tentative description is presented below. There is little doubt that the aecia belong with *C. standleyana*.

Pycnia epiphyllous, subepidermal, globoid to narrowly flask-shaped, 115–135 μ wide by 140–230 μ long, reddish brown. Aecia hypophyllous, subepidermal, cupulate, 150–200 μ wide, in small groups on reddish, often somewhat hypertrophied spots up to 7 mm. in diameter, the spots falling out to leave "shot-holes"; peridium brownish, the peridial cells ellipsoid or oblong in face-view, 15–20 × 21–30 μ, the inner wall moderately rugose, 1.5 μ (?) thick, the outer wall 3–4 μ, smooth (?); aeciospores globoid or ellipsoid, 14–19 × 18–23 μ; wall hyaline, 1 μ thick, very finely verrucose.

GYMNOSPORANGIUM SPECIOSUM Peck ?. On *Juniperus mexicana* Spreng., Dept. HUEHUETENANGO: Sierra de los Cuchumatanes, along road beyond La Pradera, km. 32, December 31, 1940, *Standley 81737*.

Positive identification of this material is not possible on the basis of available material. Standley's note on the label is as follows: "Forming elongate swellings often as thick as a man's arm." Dr. Johnston, concerning what is probably the same rust, wrote (*in litt.*) as follows: "Inclosed herewith for your files is a photograph (see figure 11) of swellings on the branches of Juniperus mexicana. These swellings reach a size of 3 ft. in length and 6 in. in diameter. . . . In any case I did not get the fungus as it is out of season. Supposedly these are similar to the swellings on Cupressus but due to a distinct Gymnosporangium."

By soaking the gall collected by Standley I was able to obtain a few teliospores as well as evidence that the telia are probably cristiform, as in *G. speciosum*. The 2–4-celled teliospores are longer than typical of the species, however, since they measure 21–26 × 75–135 μ. Only remnants of the pedicels were seen and the spores were in poor condition for study. There is a definite possibility that this rust is an undescribed species but no decision can be reached until freshly sporulating galls are available.

Thus far the genus *Gymnosporangium* is represented in Guatemala only by *G. meridissimum* Crowell on *Cupressus*, *G. guatemalianum* Crowell (aecial stage only) on *Amelanchier* and by the above rust on *Juniperus*.

Kuehneola guatemalensis Cummins, sp. nov. Pycniis non visis. Aeciis uredinoidibus confluentibus in caulibus evolutis, gallas plus minusve globulosas usque ad 3 cm. diam. efformantibus, superficie flavo-brunneis; aeciosporae late ellipsoideae, ellipsoideae vel obovoideae, 19–23 × 23–32 μ; membrana 1–1.5 μ cr., minuteque echinulata, pallide aurea; poris germ. obscuris. Urediis non visis; urediosporae in telia globoideae vel late ellipsoideae, 19–25 × 23–27 μ; membrana 1 μ cr., pallide flavida vel hyalina, minuteque echinulata; poris germ. obscuris. Teliis hypophyllis, sparsis, minutis, 0.1–0.2 mm. diam., plus minus pulverulentis, pallide flavis vel albidis; teliosporae catenulatae, ex cellulis 3–8 compositis, cellulis individuis cuboideis, oblongis vel plus minusve cuneatis, ad apicem variabiliter lobatis, 18–24 μ latis, 20–30 μ altis; membrana 1–1.5 μ cr., ad apicem 2.5–5 μ cr., fere hyalina, levi; pedicello hyalino, brevi. Statim germ.

On *Rubus tuerckheimii* Rydb., Dept. GUATEMALA: slopes of Volcán de Pacaya, between San Francisco Sales and the base of the active cone, December 20, 1940, *Standley 80704*.

The teliospores of this species are apically lobed as are those of *K. arthuri* (Syd.) Jacks. but differ in having smaller cells borne in longer chains. There is no similarity in the aeciospores or urediospores of the two species.

The description of the aecia is based upon a single gall and may require revision, therefore, when future collections reveal possible variations. Aecia of *K. arthuri*, which may similarly cause large galls, show rather wide variation in habit.

Mainsia standleyi Cummins, sp. nov. (figs. 1, 2). Pycniis (fig. 1) amphigenis, intraepidermalibus, lenticularibus, 100–180 μ diam., eparaphysatis. Aeciis uredinoidibus amphigenis, maculis lenissime inerassulatis flavo-brunneis usque 8 mm. diam. occupantibus vel ad nervos lenissime inerassatos evolutis et greges elongatos formantibus, subepidermalibus, 0.1–0.3 mm. diam. vel confluentibus, flavidis, pulverulentis; paraphysibus nullis; aeciosporae (fig. 2) obovoideae vel ovoideae, 16–23 × 24–33 μ; membrana pallide flavida vel fere hyalina 2 μ cr., ad apicem 6–12 μ cr., moderate echinulata; poris germ. obscuris. Urediis aeciis conformibus (vel nullis ?). Teliis hypophyllis, inter aecia sparsis, subepidermalibus, rotundatis, 0.1–0.3 mm. diam., pulvinatis, flavo-brunneis; paraphysibus nullis; teliosporae (fig. 2) oblongae, oblongo-ellipsoideae vel ellipsoideae, ad apicem rotundatae, deorsum attenuatae, 13–19 × 28–45 μ; membrana 1.5 μ cr., ad apicem 2.5–3.5 μ cr., pallide aureo-brunnea, levi; pedicello flavidulo vel hyalino, fragili, sporam aequante vel breviore. Statim germ.

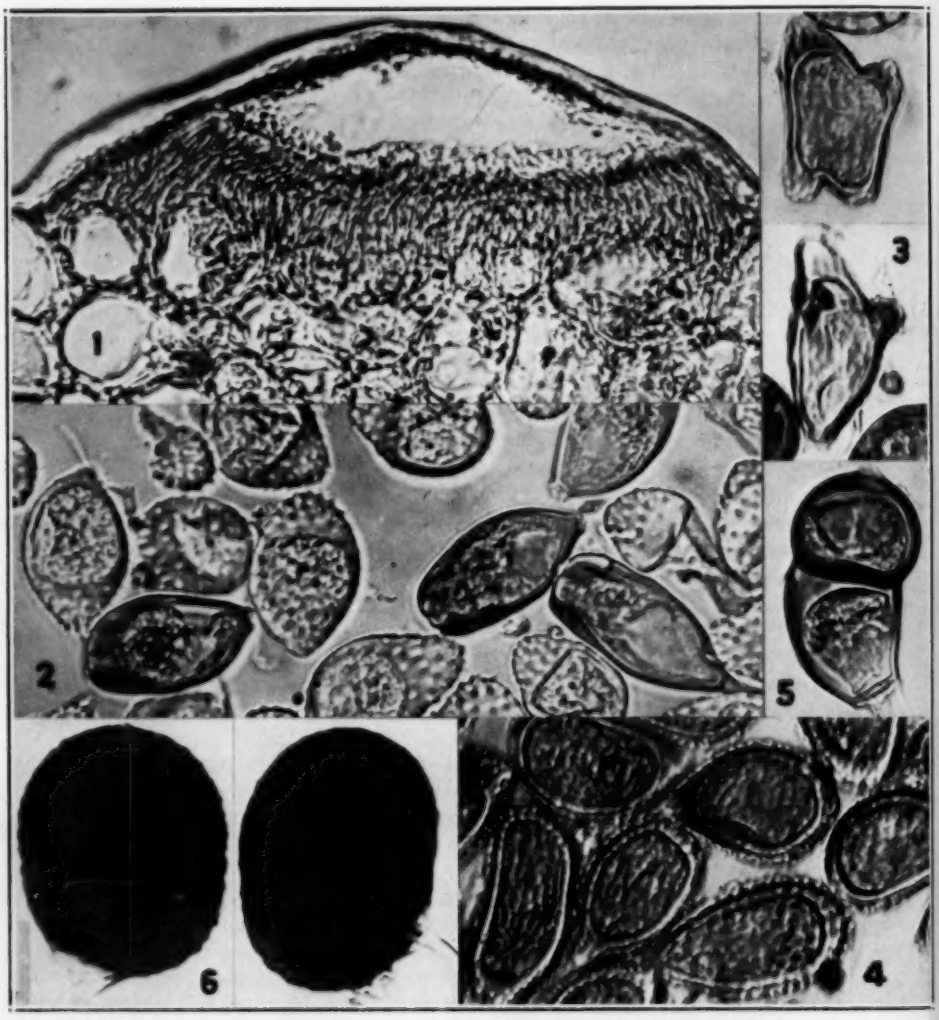

FIG. 1. *Mainsia standleyi*, freehand, unstained section of a pycnium. FIG. 2. Aeciospores and teliospores of *Mainsia standleyi*. FIG. 3. Two of the peculiar lobate urediospores characteristic of *Pileolaria standleyi*. FIG. 4. Aeciospores of *Pileolaria standleyi;* the markings tend to be longitudinally arranged. FIG. 5. One teliospore of *Puccinia degener*, a species previously known only from the uredial stage. FIG. 6. Two teliospores of *Puccinia dyschoristes*. ×800.

On *Rubus irasuensis* Liebm., Dept. ALTA VERAPAZ: damp limestone forest along the Petén highway between Campur and Socoyó, April 9, 1941, *Standley 91714*.

Mainsia standleyi differs from *M. holwayi* Jacks. in the greater apical thickening of the aeciospore wall and in the finer echinulation and from *M. peruvianum* Jacks. in having sharp round aculeae rather than longitudinally elongated markings. In addition, both *M. holwayi* and *M. peruvianum* have teliospores with uniformly thin walls.

I was unable to decide the point definitely with this material but am inclined to believe that uredia may not be formed in this species.

PHAKOPSORA VIGNAE (Bres.) Arth. On *Canavalia villosa* Benth., Dept. SACATEPÉQUEZ: along Río Guacalate, on road between Antigua and Chimaltenango, December 23, 1940, *Standley 81016*; Dept. HUEHUETENANGO: near crossing of Río San Juan Ixtán, east of San Rafael Pétzal, January 9, 1941, *Standley 83032*. On *Phaseolus macrolepis* Piper, Dept. QUEZALTENANGO: region of Las Nubes, south of San Martín Chile Verde, January 16, 1941, *Standley 83605*; along old road between Finca Pirineos and Patzulín, February 9, 1941, *Standley 86619*.

Telia, not recorded previously for this species, are present on no. 83032 and may be described as follows:

Telia hypophyllous, grouped about the uredia, blackish brown, subepidermal, crustose, 3–7 spores in thickness; teliospores variable, those in the outer layer oblong or less commonly cuboid, those in the inner layers cuboid or oblong, 6–12 × 13–23 μ; lateral walls 1 μ thick, golden or nearly hyaline, apical walls of the outermost spores 2–4 μ thick, chestnut-brown, smooth.

Hiratsuka (Bot. Mag. Tokyo **49**: 786. 1935) considers that this rust should be placed in synonymy under *Phakopsora pachyrhizi* Syd. Certainly they are similar but the teliospores described above are only about one half as large as those described by Sydow for *P. pachyrhizi* which, for the present, seems a valid reason for questioning such a treatment. Hiratsuka may be correct but until telia are found on *Vigna*, *Phaseolus*, *Eriosema*, *Dolichos* and *Teramnus* and comparative studies made it is best to accept the possibility that more than a single species may be involved.

Pileolaria standleyi Cummins, sp. nov. (figs. 3, 4). Pycniis amphigenis, in maculis purpureis 1–6 mm. diam. dense aggregatis, subcuticularibus, hemisphaericis, 50–135 μ diam. Aeciis uredinoidibus, subepidermalibus, hypophyllis, inter pycnia aggregatis, vel in petiolis et ramis junioribus deformatis dense dispositis, confluentibus, cinnamomeis, pulverulentis; aeciosporae (fig. 4) ovoideae, ellipsoideae vel oblongae, ad apicem rotundatae vel apiculatae, 16–23 × (27–) 30–35 (–37) μ; membrana cinnamomeo-brunnea, 3 μ cr., ad apicem 4–9 μ, longitudinaliter verrucosa, verrucis cuboideis vel oblongis, frequenter confluentibus; poris germ, 2 vel 3, aequatorialibus. Urediis amphigenis, subepidermalibus, sparsis, rotundatis, plus minusve pulverulentis, obscure brunneis; urediosporae (fig. 3) formam variabiles, plus minusve obovoideae, in superiore parte plerumque lobatae, rarius rotundatae, 19–26 × 28–38 μ; membrana 2 μ cr. sed ad apicem et in lobis 5–9 μ cr., cinnamomeo-brunnea, obscure longitudinaliter striata; poris germ. 2, aequatorialibus. Teliis amphigenis vel plerumque epiphyllis, subepidermalibus, in maculis purpureis 1–3 mm. diam. sparsis vel circinatis, castaneo-brunneis,

plus minusve pulverulentis; teliosporae discoideae vel globoideae, 18–26 μ alta, 24–30 μ lata; membrana 2.5–3 μ cr. vel ad apicem usque ad 4 μ cr., castaneo-brunnea, obscure rugosa vel fere levibus; poro germ. apicali; pedicello hyalino, sporam aequante.

On *Pistacia mexicana* H.B.K., Dept. BAJA VERAPAZ, rocky hills near and above Santa Rosa, in pine-oak forest, April 4, 1941, *Standley 91090.*

Pileolaria pistaciae Tai & Wei (*P. clemensiae* Cumm.), of the species which parasitize *Pistacia*, is closest to *P. standleyi* but it differs in having teliospores with longer pedicels and regularly fusiform-ellipsoid urediospores.

Few uredia are present, the infection being mainly aecial, but the peculiar lobate urediospores were seen in sufficient numbers to indicate that they are characteristic of this species and not mere abnormalities. The only other rust having similarly shaped urediospores of which I have record is *Kuehneola harrisoniae* (Syd.) Arth. & Cumm.

No previous report has been made of a *Pileolaria* on *Pistacia* in the Americas.

PROSPODIUM CONJUNCTUM (Diet. & Holw.) Cumm. On *Lippia myriocephala* S. & C., Dept. QUEZALTENANGO: along Río Samalá near Santa María de Jesús, January 25, 1941, *Standley 84636.*

This species has been collected only twice previously, on *L. pringlei* from Oaxaca, Mexico.

PUCCINIA ALIA Jacks. & Holw. On *Baccharis trinervis* (Lam.) Pers., Dept. JALAPA: vicinity of Jalapa, November 7–18, 1940, *Standley 77526.*

Since telia are not present in this collection identification cannot be positive. The aecia arise below the palisade layer and have sharply echinulate aeciospores as in *P. alia* but the spines of both aeciospores and urediospores are slightly larger than typical. *P. alia* was described from Brazil on *B. trinervis* and has not been recorded previously for North America.

PUCCINIA BERBERIDIS-TRIFOLIAE Diet. & Holw. On *Berberis fascicularis* (DC.), Dept. HUEHUETENANGO: Chémal, December 31, 1940, *Johnston 1690*; Sierra de los Cuchumatanes, along road beyond La Pradera, km. 32, December 31, 1940, *Standley 81819.*

This microcyclic species has been known previously from only the type collection made at Rio Hondo, near Mexico City.

PUCCINIA CONOCLINII Seym. (fig. 7). On *Piqueria standleyi* Rob., Dept. JUTIAPA: hills between Jutiapa and Plan de Urrutia, north of Jutiapa, October 28, 1940, *Standley 75496.*

Although this rust is common on *Ageratum*, *Conoclinium* and *Eupatorium* I can find no record of its having been collected on *Piqueria*. While differing slightly in that the teliospores tend to be narrower and commonly have the pore of the lower cell depressed the similarity is still so great that the specimen is so named with confidence.

Puccinia cuilapensis Cummins, sp. nov. (fig. 8). Pycniis et aeciis adhuc ignotis. Urediis amphigenis sed praecique hypophyllis, rotundatis, 0.1–0.3 mm. diam., flavidis, pulverulentis; urediosporae obovoideae vel late ellip-

soideae, 17–20 × 20–25 μ; membrana 1–1.5 μ cr., flavidula vel pallide aurea, moderate echinulata; poris germ. 2, aequatorialibus, obscuris. Teliis hypophyllis, rotundatis, 0.2–0.4 mm. diam., atro-brunneis, pulverulentis; teliosporae ellipsoideae, 26–30 (–32) × 37–43 (–45) μ, utrinque rotundatae, medio leniter constrictae; membrana castaneo-brunnea, 3–4 μ cr., supra poros usque ad 8 μ umbone pallidiore incrassata, moderate rugoso-verrucosa; poro superiore apicali vel plus minusve subapicali, inferiore juxta septum sito; pedicello hyalino, subpersistenti vel persistenti, plus minusve sporam aequante.

On *Salvia gracilis* Benth., Dept. QUEZALTENANGO: region of Azufral, northern slope of Volcán de Zunil, February 3, 1941, *Standley 85744*; mts. above Zunil, lower slopes of Volcán de Zunil, on road to Fuentes Georginas, February 3, 1941, *Standley 85830*. On *Salvia mocinoi* Benth., Dept. SANTA ROSA: near Cuilapa, November 20–27, 1940, *Standley 78545* (TYPE). On *Salvia* sp., Dept. SANTA ROSA: near Cuilapa, November 23, 1940, *Standley 78008*.

Only uredia are present on *Salvia gracilis* but the spores agree well with those of the type.

P. cuilapensis differs from other *Salvia* rusts having verrucose teliospores because of its yellow uredia and nearly hyaline urediospores with strictly equatorial pores. The teliospores resemble those of *P. farinacea* Long but are somewhat longer and commonly have the pore of the upper cell placed slightly to one side of the apex.

PUCCINIA DEGENER Mains & Holw. (fig. 5). On *Salvia myriantha* Epling, Dept. QUEZALTENANGO: region of Las Nubes, south of San Martín Chile Verde, January 16, 1941, *Standley 83614*; vicinity of Fuentes Georginas, slopes of Volcán de Zunil, February 3, 1941, *Standley 85954*.

P. degener has been known only in the uredial stage but no. 83614 has all spore stages present, although the aecia are too old for accurate description.

Pycnia amphigenous. Aecia amphigenous, in small groups, often on veins, peridial cells collapsed but apparently mainly ellipsoid and about 21–28 × 29–35 μ, hyaline or pale yellowish, obscurely punctate; aeciospores ellipsoid, broadly ellipsoid or globoid, 17–23 × 22–27 μ, rarely larger; wall 1.5 μ thick, hyaline or yellowish, verrucose. Uredia and urediospores as described, the spores characterized by a single germpore somewhat above the hilum. Telia hypophyllous, scattered, round, 0.1–0.3 mm. diam., pulvinate, cinnamon-brown; teliospores ellipsoid or oblong-ellipsoid, (20–) 23–26 × 36–43 (–46) μ, rounded at both ends or somewhat narrowed below, moderately constricted at the septum; wall 1.5 μ thick, light cinnamon- or golden-brown, smooth; the pore in upper cell apical, next the septum in lower cell, each covered by a small conical or hemispherical, hyaline papilla 3 μ thick, the papilla disappearing at germination, which occurs without a rest period; pedicel about one-half as long as the spore or shorter, hyaline, rather fragile.

Puccinia dyschoristes Cummins, sp. nov. (fig. 6). Pycniis et aeciis adhuc ignotis. Urediis sparsis, hypophyllis, rotundatis, 0.3–0.5 mm. diam., cinnamomeis, pulverulentis, epidermide rupta conspicue; urediosporae globoideae, late ellipsoideae vel obovoideae, 19–26 × 24–27 μ; membrana 2 μ

cr., cinnamomeo-brunnea, moderate echinulata; poris germ. 2, aequatorialibus. Teliis amphigenis, sparsis vel aggregatis, atro-brunneis, pulverulentis, plus minusve rotundatis, usque ad 1 mm. diam., epidermide rupta conspicue; teliosporae ellipsoideae, utrinque rotundatae, ad septum non vel vix constrictae, 29–36 × 39–47 μ; membrana 4–5 μ cr., ad apicem 5–8 μ, atro-brunnea, moderate rugoso-reticulata; poro superiore apicali, inferiore prope septum vel medium loculum sito; pedicello persistenti, hyalino, sporam aequante vel longiore, deorsum rugoso.

On *Dyschoriste quadrangularis* (Oerst.) Kuntze, Dept. JUTIAPA: between Jutiapa and Las Tunas, northwest of Jutiapa, November 4, 1940, *Standley 76263*.

Puccinia dyschoristes resembles *P. ruelliae-bourgaei* Diet. & Holw. in having coarsely sculptured teliospores but differs because of the larger, thicker-walled spores. The length of the teliospores equals that of *P. longiana* but the width is greater and the wall both thicker and more coarsely sculptured. *Aecidium tracyanum* Syd. occurs on *Dyschoriste* but there is no present evidence to indicate that it belongs with *P. dyschoristes*, although the latter species is probably autoecious.

The wall of the teliospores is a deep reddish brown and bilaminate but the lamination is inconspicuous because of the density of pigmentation. The inner wall is of uniform thickness, the slight thickening over the pores being due to the outer wall, which is only slightly lighter in color. Reticulation of the surface is rather irregular and not readily discernible.

PUCCINIA FUIRENAE Cooke. On *Fuirena incompleta* Nees., Dept. HUEHUETENANGO: near crossing of Río San Juan Ixtán, east of San Rafael Pétzal, January 9, 1941, *Standley 82958*.

This appears to be the first collection of *P. fuirenae* from south of the United States.

PUCCINIA INAUDITA Jacks. & Holw. On *Wedelia acapulcensis* H.B.K., Dept. CHIMALTENANGO: Las Calderas, December 16, 1940, *Johnston 1928*; Finca La Alameda, near Chimaltenango, December 11–22, 1940, *Standley 79966*. On *Wedelia filipes* Hemsl., Dept. JALAPA: vicinity of Jalapa, November 7–18, 1940, *Standley 77531*.

These are the first collections of *P. inaudita* on the genus *Wedelia*. It has previously been recorded only on *Zexmenia*.

PUCCINIA PROBA Jacks. & Howl. On *Wedelia filipes* Hemsl., Dept. RETALHULEU: vicinity of Retalhuleu, February 17–March 1, 1941, *Standley 88747*.

Species of *Wedelia* have not been reported previously as hosts for *P. proba*.

PUCCINIA REPENTINA Jacks. & Holw. (fig. 9). On *Arracacia bracteata* C. & R., Dept. SANTA ROSA: near Cuilapa, November 20–27, 1940, *Standley 77904*.

P. repentina was described on *A. xanthoriza* Bauer from Bolivia and has not been collected previously in North America. Jackson (Mycologia 23: 489. 1931) described the apical wall of the urediospores as 7–10 μ thick while in the Guatemalan specimen it is frequently as much as 15 μ. The

FIG. 7. *Puccinia conoclinii;* teliospores from *Piqueria standleyi.* FIG. 8. Teliospores of *Puccinia cuilapensis.* FIG. 9. Teliospores of *Puccinia repentina,* a species previously known only from South America. FIG. 10. Urediospores and teliospores of *Puccinia spegazziniana* on *Eleutheranthera ruderalis.* This rust is new to North America. ×800. FIG. 11. Photograph of a tree of *Juniperus mexicana* near Chémal. The galls are probably formed by a species of *Gymnosporangium* similar to or identical with *G. speciosum.* (Photo by Johnston, Dec. 31, 1940.)

teliospores may be verrucose, rugose or irregularly reticulate and are variable in size and shape and in the density of pigmentation. *P. arracachae* Lagerh. & Lindr. is also known to occur on this host in Guatemala.

PUCCINIA SEMOTA Jacks. & Holw. On *Hymenostephium cordatum* (H. & A.) Blake, Dept. CHIMALTENANGO: region of Los Positos, above Las Calderas, December 16, 1940, *Standley 80227, 80257*.

P. semota is known otherwise only from the type specimen on *Gymnolomia subflexuosa*, collected by Holway at Solola, Guatemala.

PUCCINIA SPEGAZZINIANA De T. (fig. 10). On *Eleutheranthera ruderalis* (Sw.) Sch. Bip., Dept. SANTA ROSA: along road southeast of Barberena, November 21, 1940, *Standley 77789*.

This rust has not been recorded previously from North America nor has it been reported on *Eleutheranthera*. However, I have compared it with a specimen collected on *Aspilia montevidensis* in Argentina by Spegazzini and can find no substantial difference. The urediospores are characteristically oblate-spheroid with a thin, cinnamon-brown wall and 3 or 4 equatorial or slightly subequatorial pores. The teliospores (fig. 10) are light chestnut- or deep golden-brown and measure 23–29 × 41–60 μ.

PUCCINIA SUBAQUILA Jacks. & Holw. On *Wedelia acapulcensis* H.B.K., Dept. JUTIAPA: vicinity of Jutiapa, October 24–November 5, 1940, *Standley 75205*.

This South American species has not been recorded previously from North America. Identification can be only tentative since teliospores are not present in this collection. The urediospores correspond, however, to those in Holway's South American material.

Ravenelia mere Cummins, sp. nov. Pyeniis hypophyllis, hemisphaerico-conicis, 80–130 μ diam., subcuticularibus. Teliis amphigenis vel praecique epiphyllis, 0.5–3 mm. diam., atro-brunneis, subepidermalibus; capitulis teliosporarum convexis, atro-brunneis, levibus, 50–85 (–100) μ diam., ex sporis 4–8 in omni directione compositis; sporis individuis unicellularibus, 10–15 μ diam.; membrana 1 μ cr. flavida, ad apicem 4–6 μ cr. obscure castaneo-brunnea; cystidiis eodem numero quo cellulis marginalibus, capitulis adpressis, in aqua intumescentibus et ruptis; pedicello hyalino vel flavido, 125–200 μ longo sed deciduo, ex hyphis numerosis composito.

On *Lonchocarpus michelianus* Pittier, Dept. JUTIAPA: vicinity of Jutiapa, October 24–November 5, 1940, *Standley 75109* (TYPE). On *Lonchocarpus rugosus* Benth., Dept. RETALHULEU: San Felipe, January 13, 1917, *E. W. D. Holway 706*.

The host of the Holway specimen was originally supposed to be *Brogniartia* sp. and the rust was reported by Arthur (Am. Jour. Bot. **5**: 427. 1918) as *Ravenelia similis* (Long) Arth. Mr. Standley recently examined the host and found it to be *Lonchocarpus rugosus*.

There are two other species of *Ravenelia* on *Lonchocarpus* which may be microcyclic. One, apparently undescribed, was collected in Brazil and will probably be described by A. P. Viégas. It differs in habit and in having individual spores 22–29 μ in diameter. The other is *R. lonchocarpicola* Speg., described in 1925 (Revista Argent. Bot. 1: 131) on *L. nitidus* in Argentina.

Through the courtesy of Dr. Lindquist I have seen this species. The teliospore-heads are slightly smaller and the individual cells 19–26 μ in diameter. The species are probably closely related.

Uredo colubrinae Cummins, sp. nov. Urediis hypophyllis, laxe aggregatis vel plus minusve aequaliter sparsis, rotundatis, 125–175 μ diam., pustulatis, subepidermalibus, diu tectis, flavidis; paraphysibus peripherales hyphoideis, incurvatis, inconspicuis, inferne conjunctis; urediosporae ellipsoideae vel obovatae, 12–17 × 18–26 μ; membrana 1 μ cr. hyalina vel pallide flavidula, subtilissime echinulata; poris germ. obscuris, verisimiliter 4, aequatorialibus.

On *Colubrina ferruginosa* Brongn., Dept. QUEZALTENANGO: below Colomba, on road toward Asintal, Feb. 20, 1941, *Standley 87894*.

When telia are discovered this species and *Uredo reissekiae* Syd. may prove to be closely related.

UREDO ERYTHRINAE P. Henn. On *Erythrina berteroana* Urban, Dept. CHIMALTENANGO: region of Los Positos, above Las Calderas, December 16, 1940, *Standley 80151;* Dept. QUEZALTENANGO: near Río Samalá, along road between Zunil and Cantel, January 18, 1941, *Standley 83940;* Dept. RETALHULEU: vicinity of Retalhuleu, February 17–March 1, 1941, *Standley 88716*.

Originally described from the Congo and known to occur also in Ceylon and the Philippines, *U. erythrinae* has been reported for the Americas only from Ecuador where Sydow collected it in 1937 on *Erythrina* sp.

UREDO FICINA Juel. On *Ficus involuta* (Liebm.) Miq., Dept. SANTA ROSA: plains north of Los Cerritos, on road between Chiquimulilla and El Ahumado, December 7, 1940, *Standley 79545*.

Uredo ficina has received varied treatment. Arthur (N. Am. Flora **7**: 103. 1907) placed it in the genus *Physopella* but later (*l. c.* p. 696. 1925) included it in synonymy under *Cerotelium fici*. Sydow (Monogr. Ured. **3**: 417. 1915) listed the species as *Physopella fici*, although he did not accord *Physopella* full generic rank, and pointed out differences between it and *Kuehneola fici* (*Cerotelium fici*).

Uredo ficina differs from *C. fici* in having larger, more strongly echinulate urediospores and large, branched paraphyses. These differences are obvious and constant and until telia are found for *U. ficina* confusion can be avoided by citing it under the form-genus *Uredo*.

Uredo machaeriicola Cummins, sp. nov. Urediis praecique hypophyllis, rotundatis, 0.15–0.3 mm. diam., cinnamomeo-brunneis, sparsis vel laxe aggregatis; paraphysibus peripherales numerosis, incurvatis, cylindraceis, ad apicem acuminatis vel rotundatis, 4–7 × 40–75 μ; membrana 1.5–3 μ cr., hyalina vel flavidula; urediosporae late ellipsoideae vel obovoideae, 12–15 × 14–18 μ; membrana flavo-brunnea, minuteque echinulata, 1–1.5 μ cr.; poris germ. obscuris.

On *Machaerium biovulatum* Micheli, Dept. RETALHULEU: vicinity of Retalhuleu, February 17–March 1, 1941, *Standley 88557*.

This species differs from *U. machaerii* Diet. in having abundant paraphyses and in being foliicolous without causing hypertrophy or distortion. Its spores are of approximately the same size. *U. pusilla* Kern, Thurston & Whetzel, while having paraphyses, differs by reason of its large spores.

UREDO MUEHLENBECKIAE Jacks. & Holw. On *Muehlenbeckia tamnifolia* (H.B.K.) Meissn., Dept. QUEZALTENANGO: lower north slopes of Volcán de Santa María, above Palojunoj, January 15, 1941, *Standley 83551;* mts. southeast of Palestina, on old road to San Juan Ostuncalco, January 21, 1941, *Standley 84321.*

U. muehlenbeckiae is a new species for North America, having been recorded previously only from Ecuador and Bolivia.

Uredo obnixa Cummins, sp. nov. Uredia hypophylla, sparsa, ovoidea vel linearibus, 0.4–1.0 mm. longa, bullata, epidermide tecta, longitudinaliter dehiscentibus, cinnamomea; urediosporae obovoideae vel ellipsoideae, 17–25 × 25–33 μ; membrana 2 μ cr., cinnamomeo-brunnea, moderate echinulata; poris germ. 2, valde superaequatorialibus.

On *Cyperus melanostachyus* H.B.K., Dept. HUEHUETENANGO: about Laguna de Ocubilá, east of Huehuetenango, January 7, 1941, *Standley 82692.*

Among the *Cyperus* rusts which have superequatorial pores *P. obvoluta* Jacks. & Holw. is most like *Uredo obnixa*, but it has smaller uredia, slightly smaller and paler urediospores and pores situated nearer the equator. The spores of *U. obnixa* are also more strongly flattened and thicker-walled on the pore-bearing sides. Discovery of telia would readily decide the possible relationship with *P. obvoluta* since it has characteristic telia with stromatic paraphyses and nearly colorless teliospores with brown pedicels.

Uredo quichensis Cummins, sp. nov. Uredia epiphylla, subcuticularia, sparsa, rotundata, 0.1–0.2 mm. diam., flavo-brunnea; paraphysibus copiosis, capitatis, 10–16 × 40–65 μ, membrana 1 μ cr., hyalina vel ad apicem 1.5–2 μ cr. et aureo-brunnea; urediosporae ellipsoideae vel oblongo-ellipsoideae, 16–19 × 25–30 μ; membrana 1.5–2 μ cr. vel ad apicem et basim usque ad 3 μ cr., cinnamomeo-brunnea, dense echinulato-verrucosa; poris germ. 8–10 bizonatis instructis.

On *Calliandra conzattiana* (B. & R.), Dept. EL QUICHÉ, oak forest along road to Aguacatán, near the boundary of Dept. Huehuetenango, December 27, 1940, *Standley 81393.*

Uredo quichensis differs from *Ravenelia bizonata* Arth. & Holw. in having paraphyses with a thin apical wall and larger, uniformly and more coarsely sculptured urediospores whose wall is thicker. The species undoubtedly will prove to be a *Ravenelia.*

Uromyces calopogonii Cummins, sp. nov. Uredia subepidermalia, hypophylla, pulverulenta, cinnamomeo-brunnea, rotundata, 0.2–0.3 mm. diam.; urediosporae globoideae vel late ellipsoideae, 15–17 × 16–19 μ; membrana 1–1.5 μ cr., minuteque echinulata, pallide cinnamomeo-brunnea; poris germ. 4, aequatorialibus. Telia uredia conformibus sed castaneo-brunnea; teliosporae late ellipsoideae, ovoideae vel obovoideae, utrinque rotundatae vel deorsum plus minusve attenuatae, 13–16 × 16–19 μ; membrana pallide castaneo-brunnea, minuteque verrucosa, 1.5–2 μ cr., ad apicem 2.5–3 μ cr.; pedicello hyalino, brevi, fragili.

On *Calopogonium galactioides* (H.B.K.) Benth., Dept. CHIMALTENANGO: Finca La Alameda, near Chimaltenango, October 26, 1936, *Johnston 165;* December 11–22, 1940, *Standley 79808* (TYPE); between Chimaltenango and San Martín Jilotepeque, December 22, 1940, *Standley 80947.*

Calopogonium has not been reported previously as a host for species of the Uredinales. *U. calopogonii* is notable for its small urediospores and teliospores.

UROMYCES SCLERIAE P. Henn. On *Scleria bracteata* Cav., Dept. ALTA VERAPAZ: Finca Samac, northwest of Cobán, March 23, 1941, *Standley 89700*.

This species, originally described from South America, has not been recorded previously for Central America. Both uredia and telia are present, the urediospores characteristic because of the apically thickened wall.

Uropyxis diphysae (Arth.) Cummins, comb. nov. (*Calliospora diphysae* Arth., Bot. Gaz. **39**: 391. 1905.) On *Diphysa floribunda* Peyr., Dept. HUEHUETENANGO: near crossing of Río San Juan Ixtán, east of San Rafael Pétzal, January 9, 1941, *Standley 82872*.

This species has apparently never been transferred to *Uropyxis*, although *Calliospora* is no longer recognized as a valid genus.

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INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Papers that relate exclusively to bacteriology, forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

The Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. **The different subjects as classified below may now be ordered separately** (but no orders will be taken for less than one year's issue in any classification). Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

The Index to American Botanical Literature is classified under 8 headings as follows: Plant Taxonomy and Floristics (exclusive of fungi); Morphology (including anatomy, and cytology in part); Plant Physiology; Mycology and Phytopathology; Genetics (including cytogenetics); Paleobotany; Ecology and Plant Geography; General Botany (including biography). It is realized that some articles do not fall readily in any of these classifications, and users of the Index interested in a particular topic are requested to examine also classifications which may include closely related topics.

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